WATER PLANT OPTIMIZATION STUDY

THUNDER BAY WATER SUPPLY

DECEMBER 1993

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Please note that some of the recommendations contained in this report may have already been completed at time of publication. For more information, please contact the local municipality, or the Water Resources Branch of the Ministry of Environment and Energy.

Note, all references to Ministry of the Environment in this report should read Ministry of Environment and Energy.

INTRODUCTION AND TERMS OF REFERENCE

The Ontario Ministry of the Environment has undertaken Water Plant Optimization Studies at a number of locations. The purpose, as stated in the Terms of Reference, is to document and review present conditions, and determine an optimum treatment strategy for contaminant removal at the plant, with emphasis on particulate materials and disinfection processes.

The Water Plant Optimization Studies are also being co-ordinated with the Ministry of the Environment's Drinking Water Surveillance Program (DWSP), since a plant process evaluation is required for each plant entering the program. DWSP provides a continuously updated base of information on water plants and water quality.

The City of Thunder Bay draws its water from two sources; Lake Superior and Loch Lomond. For the convenience of the reader, this report is split into two parts, dealing with the Lake Superior and Loch Lomond supplies and treatment individually. The Lake Superior supply is covered in Part 1, and the Loch Lomond supply in Part 2.

The Bare Point Water Treatment Plant is located in the northeast of the City of Thunder Bay. It draws its raw water from Lake Superior. This supply presently serves all areas north of William Street, the former Fort William/Port Arthur boundary.

The Bare Point Plant is a direct filtration plant, and supplies good quality treated water that meets or exceeds all Ministry of the Environment Guidelines.

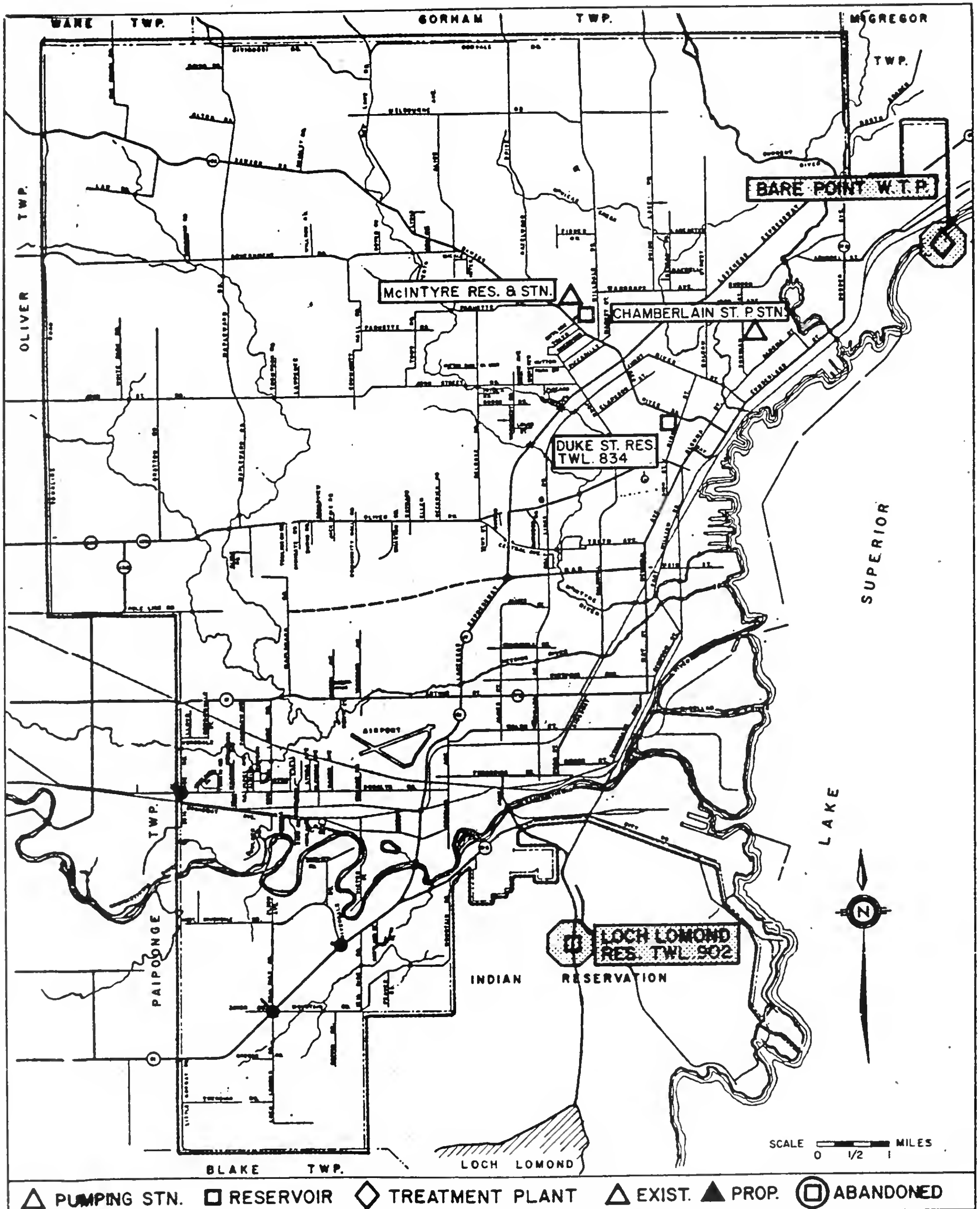
The plant is well maintained and operated, although some limitation on length of filter runs exists at the plant design filter rates.

The other plant using Loch Lomond as the raw water source is situated at the south of the city in the area formerly known as Fort William. This supply serves the remainder of the area of Thunder Bay not supplied by the Bare Point Plant. Loch Lomond is at an elevation approximately 100 m above Lake Superior so the supply is operated entirely by gravity.

The Loch Lomond Treatment Plant provides aggression control and disinfection only, and does not meet the Ministry of the Environment Guidelines for treatment of surface waters (a minimum of chemically assisted coagulation and filtration). Some quality parameters, therefore, exceed the Guidelines, although Turbidity is generally below the 1.0 NTU limit.

The locations of these two water treatment plants are shown on Figure 1.

This overall study has been undertaken in accordance with the Terms of Reference attached to this report as Appendix D.



APPROVED BY	CITY OF THUNDER BAY WATER PLANT OPTIMIZATION STUDY	The Proctor & Redfern Group Consulting Engineers and Planners THUNDER BAY TORONTO
	LOCATION PLAN	FIGURE No. 1 REV.

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PART 1

BARE POINT WATER TREATMENT PLANT

WATER PLANT OPTIMIZATION STUDY
THUNDER BAY, BARE POINT WATER TREATMENT PLANT

SUMMARY OF FINDINGS AND RECOMMENDATIONS

The Optimization Study of Bare Point is the start to an ongoing documentation of the operation of the plant. The study is a review of present conditions with emphasis on determining an optimum treatment strategy for removal of particulate matter and improving the disinfection processes.

The Bare Point Treatment Plant is well maintained and operated. The operational staff are diligent and motivated and strive to produce the best quality water to the City. In this regard, the plant has made advancements to optimize water quality; however, upon review of the plant, areas of further improvement and study have been identified and are summarized as follows:

- Examine the current state and gradation of filters by undertaking a sieve analysis, and annually check the total filter media depth

- Perform pilot studies to evaluate the optimum usage of coagulants and coagulation aids

- Examine the effects of rapid mixing on chemical coagulation and particulate removal

- Improve dosage locations, measurement and mixing of coagulant chemicals, in order to enhance the coagulation stage of the direct filtration process

- Examine the use of alternative coagulants

- Conduct plant scale tests on operation of the flocculation tanks under varying flow conditions (summer and winter) and investigate alternative means of varying flocculation energy. At the same time, consider replacement of the wooden flocculator baffles with stainless steel

- Provide separate scales to permit individual weighing of pre and post-chlorine feeds

- Investigate the discrepancy between raw and treated water flows

- Adopt a record keeping program using a standard format, preferably based on a computer with a spreadsheet software package.

SECTION A - RAW WATER SOURCE

SECTION A RAW WATER SOURCE

A.1. Source

The Bare Point Water Treatment Plant takes raw water from Lake Superior just to the north-east of the City of Thunder Bay. The raw water enters the low lift pumping station through two 600 mm diameter intakes. The combined intake is located in a water depth of 10 m, measured from the average lake level to the top of the screen. The intakes are 730 m long.

A.2 Physical Parameters

The raw water characteristics are shown in the following Table 1 and are compared with the treated water in Table 2. Over the three year study program, it was observed that the raw water turbidity fluctuated between 0.29 and 1.90 FTU. Normally, the turbidity levels are between 0.4 and 0.7 FTU. The raw water colour varies from 2 to 10 TCU but on average is found to be less than the Ministry of the Environment guideline of 5 TCU.

A.3 General Chemistry

The raw water alkalinity and hardness were moderately low, with the alkalinity ranging from 40.0 to 49.2 mg/L throughout the study period. The hardness varied from 42.7 to 49.6 mg/L. The pH of the raw water varied between 6.9 and 8.1.

Results from the Drinking Water Surveillance Programme for 1984, show that Total Kjeldahl Nitrogen (TKN) varied between 0.12 and 0.21 mg/L, which was occasionally above the Drinking Water Objective of 0.15 mg/L. In 1983 TKN varied between 0.12 and 1.40 mg/L, with an average of 0.35 mg/L.

A.4 Bacteriological

The raw water from Lake Superior contains total fecal coliforms and fecal streptococci during various times of the year. The levels of bacteria are elevated, particularly between May and October. During these periods, average levels are as high as 208 per 100 ml for total coliform, 4.5 (average result) per 100 ml for fecal coliform and 9 per 100 ml for fecal streptococcus. In all cases the disinfection process successfully eliminated all these bacteriological contaminants. These results are tabulated and compared in Table 4, Section F.2.

Table 1

Bare Point - Raw Water

Chemical Parameter	Range	MOE Objectives
pH	6.9-8.1	6.5-8.5
Hardness ($CaCO_3$)(mg/L)	42.7-49.6	80-100
Alkalinity ($CaCO_3$)(mg/L)	40.0-49.2	30-500
Colour (HU.)*	2-10	<5 TCU**
Turbidity (FTU)*	0.29-1.90	<1.0NTU**
Conductivity (umhos/cm)	97-106	
Magnesium (mg/L)	45.6-47.9	
Nitrogen Total Kjeldahl (mg/L)	0.12-0.21	<0.15
Nitrate (mg/L)	0.25-0.39	<10.0
Phosphorous Filtered Reactive (mg/L)	<0.001-0.002	
Phosphorous Total	0.004-0.015	
Iron (mg/L)	<0.05-0.10	<0.3
Aluminum (mg/L)	0.001-0.01	<0.1
Dissolved Organic Carbon (mg/L)	13	<5.0

*Plant Record Units

**Guideline Units

The data in this Table has been obtained from a combination of data from Thunder Bay Annual Reports and the draft Distribution System Survey undertaken in 1986/87 by Proctor & Redfern Limited for the Ministry of the Environment.

Table 2
Bare Point Raw and Treated Water

Chemical Parameter	Raw Water Range	Treated Water Range	MOE Objectives
pH	6.9-8.1	6.9-7.3	6.5-8.5
Hardness($CaCO_3$)(mg/L)	42.7-49.6	36.8-48.6	80-100
Alkalinity($CaC)_3$(mg/L)	40.0-49.2	32.6-48.1	30 - 500
Colour (H.U.)	2-10	1-<5	<5TCU **
Conductivity (umhos/cm)	97-106	101-111	-
Iron (mg/L)	<0.05-0.10	<0.05-<0.37	<0.3

** Guideline Units

The data in this Table has been derived from the same sources used for Table 1.

SECTION B - FLOW MEASUREMENT

SECTION B FLOW MEASUREMENT

B.1 Raw

Raw water flow is measured with a 900 mm diameter Universal insert venturi constructed from fiber reinforced plastic. The Model 181 venturi tube was manufactured by BIF. The raw water venturi and the associated indicator/transmitter were rated in imperial units and hence the metric units given below are direct conversions. This is also true of the other measuring devices in B.2 to B.4 below:

pressure differential:	-	0-4.06 metres W.C.(0-160 inches)
maximum rated flow:	-	181.8 ML/d (40 MIGD)

The raw water flow range was from 20.0 ML/d to 53.5 ML/d during the study period and therefore the venturi was operating in a 3.4 to 9.1:1 range.

B.2 Treated

There are presently two 600 mm diameter treated water mains leaving the Bare Point Plant and each has its own meter and indicating transmitter. There is also a 900 mm diameter venturi for a future 900 mm main.

The meters are:

600 mm, Herschell standard venturi, 45.45 ML/d rated capacity
600 mm, Herschell standard venturi, 45.45 ML/d rated capacity
900 mm, Herschell standard venturi, 181.8 ML/d rated capacity

The two 600 mm venturi tubes are located in the meter chamber in the high lift pumping area. Presently the 900 mm venturi and associated discharge main are connected downstream of the 600 mm venturi on the pipeline located on the north side of the chamber. The City is constructing a 900 mm diameter pipeline to the water treatment plant and eventually the 900 mm

venturi will be connected to a dedicated pipeline leaving the plant. The two 600 mm venturis have the same pressure differential and were rated in imperial units. The 900 mm venturi is not operational and will only be used once the 900 mm main is constructed. The differentials for the venturi tubes are as follows:

600 mm	0-2.567 metres W.C. (0-101.05 inches)
900 mm	0-4.064 metres W.C. (0-160 inches)

The totalled treated water flow range was from 22.0 ML/d to 49.2 ML/d during the study period.

B.3 Backwash

There are two backwash pumps which discharge into a common metered header. The Model 182 backwash water insert venturi manufactured by BIF has the following characteristics:

pressure differential:	-	0-5.359 metres W.C. (0-211 inches)
maximum rated flow:	-	150.0 ML/d (83 MIGD)

B.4 Filters

There are three filters in the Bare Point Plant, each with its own separate meter. The flow meters are 450 mm venturis with an integral rate of flow control valve. The meters and integral valve are Model 610 manufactured by BIF and have the following characteristics:

pressure differential	-	0-1.524 metres W.C. (0-60 inches)
maximum rated flow:	-	37.9 ML/d (8.33 MIGD)

The filter rate is set through a master rate setter located on the filter control console in the filter gallery. The rate setter sets the percentage of total rated flow that the plant will output from the filters. As an example, the total filter

flow range is 0-113.59 ML/d which corresponds to 0-100 percent on the master rate setter. Therefore if the master rate setter is set for 40 percent, the plant will produce 45.4 ML/d. Since there are three filters, each filter is normally set to operate at 15.1 ML/d.

B.5 Validity

There are no reported problems with the accuracy of the metering at the plant. The meters are checked and zeroed each month and calibrated with a manometer yearly by a qualified instrument technician. The flow data in Table 1.0 of the Appendix shows data with no anomalies nor apparent difficulties. Maximum raw and treated flows throughout the study period were in the month of July whereas minimum flows for raw and treated water vary as shown in the following Table:

Minimum Day Flow

	1983	1984	1985	1986
Raw	Feb.	June	Dec.	Sept.
Treated	Jan.	Feb.	Aug.	Sept.

The per capita flow data tabulated in the following table demonstrates the minimum average and maximum day actual recorded for the area of the City serviced by the Bare Point Plant. Also shown in the same table is the minimum average and maximum day flows per capita for the area of the City serviced by the Loch Lomond supply.

Per Capita Consumption (L/day/capita)

	1983	1984	1985	1986
Population				
Bare Point Area	55,006	54,560	55,526	56,116
Loch Lomond Area	50,876	52,083	51,063	50,050
TOTAL	105,882	106,643	106,589	106,166
Maximum				
Bare Point	846	798	882	876
Loch Lomond	1,142	981	1,179	1,074
Minimum				
Bare Point	510	496	409	479
Loch Lomond	440	480	304	731
Average				
Bare Point	593	630	652	672
Loch Lomond	724	687	686	859
Max/Average				
Bare Point	1.43	1.27	1.35	1.3
Loch Lomond	1.58	1.43	1.72	1.25

The higher maximum day to average day ratio in the area serviced by the Loch Lomond supply is due to the larger proportion of industries located in this area.

B.6 Flow Recording

The raw water flow is continuously recorded and totalized on a strip chart recorder and totalizer in the control room. The totalized flow is recorded every hour on the daily record and totalled for the day.

Similarly, the total treated water flow leaving the plant is summated on a strip chart recorder and totalized continuously in the control room. The treated

flow is recorded individually every hour on the daily record and combined for the daily total.

The backwash water flow is indicated on the transmitter and also on the filter control console which is located in the filter gallery. The flows are manually totalized after each filter backwash.

SECTION C - PROCESS COMPONENTS

SECTION C PROCESS COMPONENTS

C.1 General

This section includes detailed information on the unit processes and systems within the Bare Point Water Treatment Plant. This section also includes a series of photographs and drawings to illustrate the major plant components and chemical feed systems.

C.2 Design Data

(a) Plant Capacity

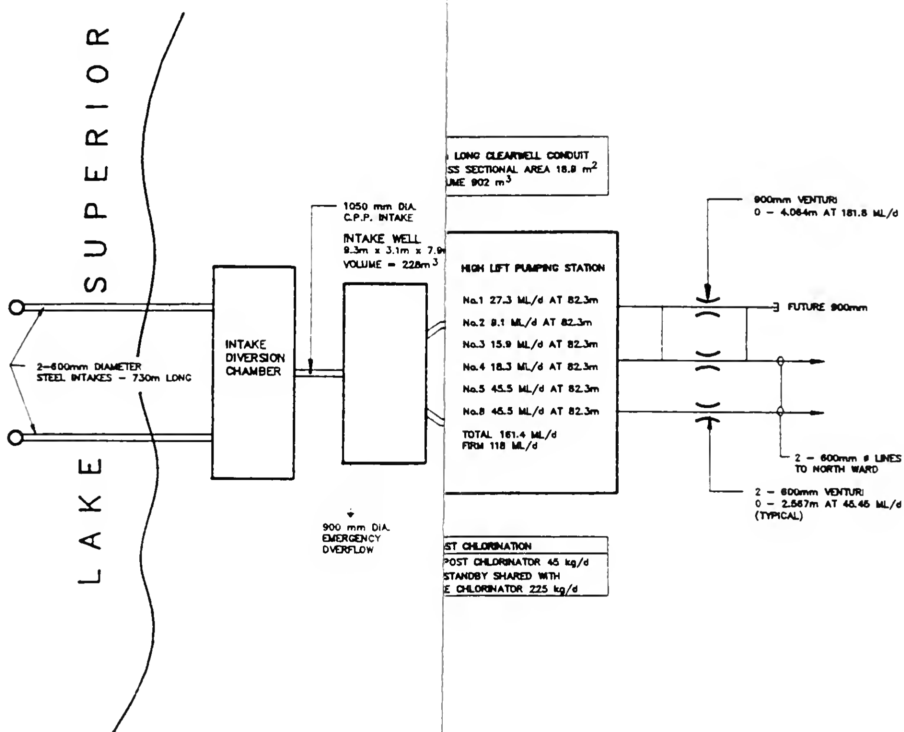
The Bare Point Plant was constructed in 1977/78 and was designed to produce 90.9 ML/d (20MIGD). The plant was designed for direct filtration which consists of flocculation and filtration without the sedimentation process.

The average daily flow over the three year study period was 39 ML/d. Hydraulic limitations exist at the plant, namely the intake capacity and until recently, the delivery of treated water from the plant to the distribution system. If the level of Lake Superior falls below 182.80 metres the intake is limited to a hydraulic capacity of 68.2 ML/d.

The capacity of the treated water transmission main is currently limited to 62.8 ML/d.

(b) Intake

The two intakes are constructed of steel pipe, are 600 mm in diameter and each extends 730 metres into Lake Superior. The steady state intake velocity at 59.1 ML/d is in the order of 1.17 m/sec, based on a Lake Level of 183.480 m. The average Hazen William friction coefficient "C" is 77 with a range of 74 to 80.



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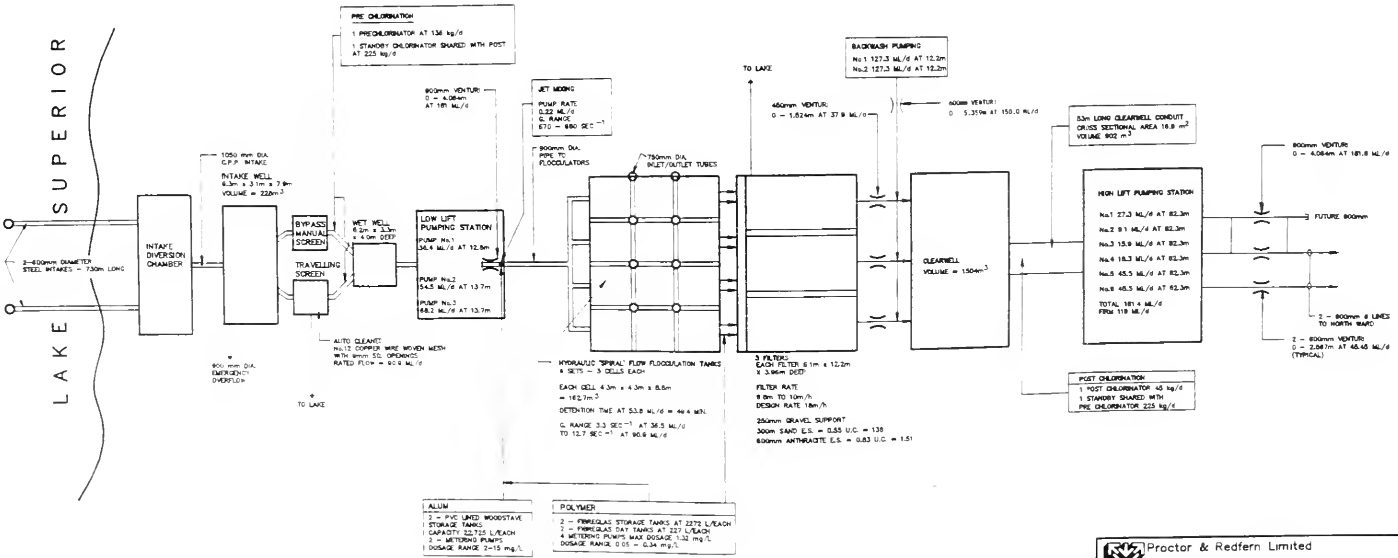
WATER PLANT OPTIMIZATION STUDY

THUNDER BAY (BARE POINT) WATER TREATMENT PLANT
BLOCK FLOW DIAGRAM

MARCH '88



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WATER PLANT OPTIMIZATION STUDY

THUNDER BAY (BARE POINT) WATER TREATMENT PLANT
BLOCK FLOW DIAGRAM

MARCH '88

The determination of the Hazen Williams 'C' factors was carried out by Gore and Storrie Limited for the City in June 1970. A report prepared by Gore & Storrie described the methodology used in calculating and measuring the 'C' values. The report was made available to Proctor and Redfern Limited for the purposes of this study.

The present intakes discharge to an intake diversion chamber which is connected to the intake lift pump well via a 1050 mm diameter pipeline. The intake well has a 900 mm diameter overflow set at 184.100 m and this discharges back into the Lake.

Subsequent to the study period, the City has commenced construction of a new intake. When completed late in 1991, the 1,350 mm dia. pipe will extend 700 m into Lake Superior, just north of the existing intakes. The existing intakes will remain for emergency use.

(c) <u>Screening</u>

The screening system at the Bare Point Plant consists of one fixed screen and one travelling screen. The travelling screen was manufactured by FMC Limited. The screens are located between the intake and low lift pumping wells.

The screen material consists of No. 12 standard gauge copper wire woven in a square mesh with 9 mm openings. The screen is rated for a flow of 90.9 ML/d.

The screen is 1.88 m wide by 9.45 m deep and a differential pressure measurement of 0-500 mm (adjustable) is used to automatically initiate screen wash once the set point has been reached. The screen rotates 1.5 revolutions after the differential pressure has gone below the set point. A timer is also set to wash the screen automatically every 24 hours regardless of the differential. The wash water from the screens is returned back to the Lake.

(d) <u>Low Lift Pumping</u>

The Low Lift Pumping Station consists of two concrete chambers. The first is the intake well which measures 9.3 m x 3.1 x 7.9 m deep, while the other chamber is the wet well which measures 8.2 m x 3.3 m x 4.0 m deep, and is located beneath the low lift pump floor.

The ratings for the raw water pumps are as follows:

Pump No.	Capacity L/s	Head m	Type	KW	Manufacturer
1	421	12.8	Vertical Centrifugal	93	Allis-Chalmers
2	631	13.7	Vertical Centrifugal (mixed flow)	112	Allis-Chalmers
3	789	13.7	Vertical Centrifugal (mixed flow)	187	Allis-Chalmers

The installed station capacity is 159.1 ML/d (1841 L/s) with a firm station capacity (No. 3 pump out of service) of 90.9 ML/d (1043 L/s) under a normal power mode. Under emergency power, the No. 1 pump can be operated by a 350 KW diesel generator (after a three minute delay) and thereby provide limited capacity of 36.4 ML/d (421 L/s).

(e) <u>Flash Mixing</u>

This unit process is extremely important in most treatment plants in order to properly disperse the active coagulant species. Without this unit process,

proper hydrolysis, polymerization and complexation cannot be adequately achieved.

At Bare Point, aluminum sulphate and polyelectrolyte solution are injected into the 900 mm raw water main just as it leaves the low lift pumping station (see Figure No. 2). In order to provide more turbulence and hence additional mixing, an "alum assist" pump rated at 2.55 l/s provides raw water to initiate a higher exit velocity at the point of injection. A sketch of this system is provided on the following page. As an example, the exit velocities for the aluminum sulphate and polymer solution lines at the point where they enter the 900 mm diameter raw water main are:

	Aluminum Sulphate*	**Polymer***
with assist pump	1.75 m/s	1.83 m/s
without assist pump	0.032 m/s	0.11 m/s

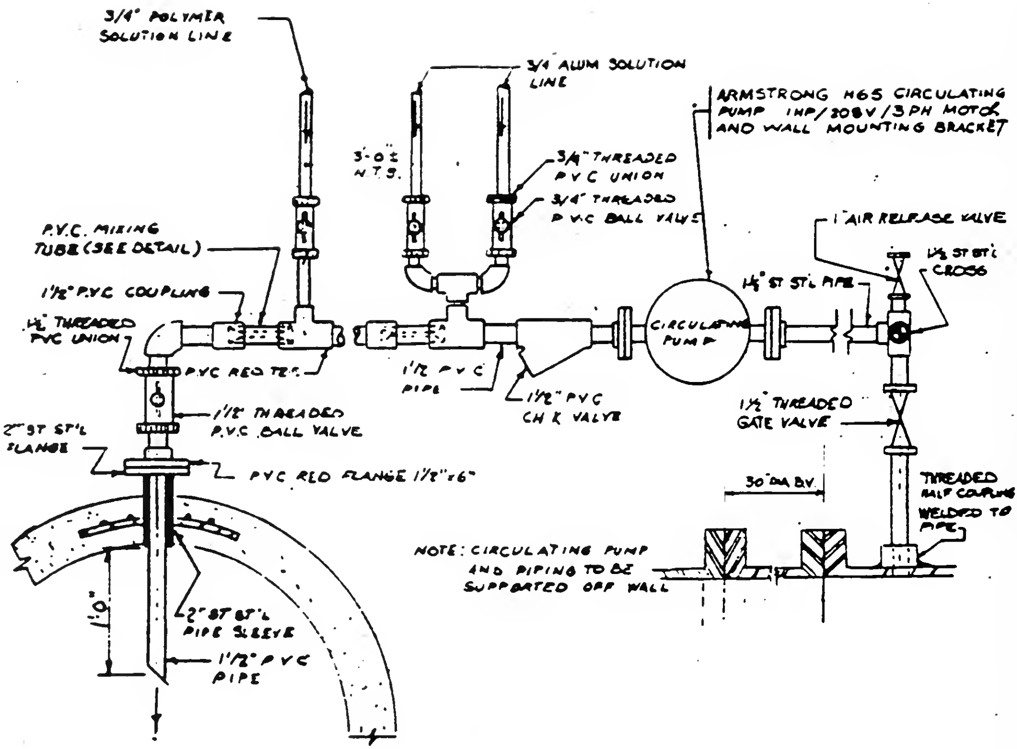
* based on maximum capacity of metering pump.

The velocity gradient "G" values obtained using this system are between 670 sec^{-1} and 950 sec^{-1}, for raw water flows of 20.8 ML/d to 68.2 ML/d.

(f) **Flocculation**

This unit process consists of 4 flocculation units with 3 cells per unit. Flow enters the first cells through 450 mm diameter motorized sluice gates. The tanks are covered with reinforced concrete roof slabs with access from the outside through top access manways.

The flow enters the first cell at the bottom of the tank, spirals to the top and then flows downwards into the following cell through a 750 mm diameter tube. The flow then enters the second cell at the bottom and spirals upwards to exit through a 750 mm tube. This pattern continues through each cell. After the third cell, the flow spirals upwards and enters the filter influent channel



Based on Original drawing prepared by Gore & Storrie Limited.

Drawn by	CITY OF THUNDER BAY WATER PLANT OPTIMIZATION STUDY	Proctor & Redfern Limited Consulting Engineers & Architect Toronto Thunder Bay
Ckd. by	ALUM & POLYMER INJECTION SYSTEM	Scale N.T.S. FIGURE No. 2

through two 600 mm x 750 mm openings. This flow pattern occurs in each of the four flocculation units. (Refer to drawings M5 and M9 in the Appendix for layout details).

Each cell of the flocculator is 4.3 m x 4.3 m x 8.8 m deep. Based on the flow through the plant and utilizing all four units, the detention times through the flocculators are as follows:

Detention Time

Plant Flow ML/d	**Flow per Vessel**	**Per 3 Stage Vessel (minutes)**
36.4	9.1	60.4
60.0	13.4	49.4
90.9	22.7	29.2

These flows represent the flow from one low lift pump, and approximately 66% and 100% of the plant rated flow respectively.

The mixing velocity gradients in the flocculation tanks have been estimated. This is based on a mixing energy input equivalent to the loss of momentum of the water entering the tanks. The loss of momentum is translated as a loss of driving head through each stage of the flocculator and is mainly attributable to the loss encountered in the 750 mm tube which takes the liquid from the upstream vessel and conveys it down into the following vessel. The actual energy lost can be obtained by measuring the headloss across the flocculators.

Generally useful velocity gradients range from 100 to less than 10 sec^{-1}. Typically for these types of processes, if flows are too low, the resultant velocity gradient and rate of particle aggregation becomes insufficient, whereas if the flows are too high, excessive headloss across the flocculators can be experienced. At high flows, surface erosion and floc splitting mechanisms occur which cause breakup of the floc.

The dimensionless parameter "Gt", which is the product of velocity gradient and duration of mixing, is a useful parameter. Values within the range of 50,000 to 125,000 are desirable.

Plant Flow/Unit ML/d	**Detention Time Minutes**	**G sec^{-1}**	**Gt**
9.1	60.4	3.3	11,960
13.4	49.4	5.8	17,200
22.7	29.2	12.7	22,250

Estimated velocity gradients at 5°C utilizing 2, 3 or 4 flocculators at various flows are as follows:

		G (sec^{-1})	
Plant Flow/Unit ML/d	**4 floc tanks**	**3 floc tanks**	**2 floc tanks**
9.1	3.3	5.0	9.2
13.4	5.8	8.9	17.1
22.7	12.7	19.4	35.5

At a plant flow of 68.2 ML/d (the current maximum intake capacity) i.e. 17.0 ML/d per flocculation vessel, the velocities through the inlet ports to each stage are as follows:

Inlet	**Velocity**
First Stage	1.24 m/s
Second Stage	0.43 m/s
Third Stage	0.43 m/s
Filter Influent	0.21 m/s

(g) **Filters**

The plant contains three dual media filters, each 6.1 m x 12.2 m x 3.96 m deep and consisting of the following physical system:

Underdrain: Leopold compound duplex tile filter, 194 - 6 mm diameter orifices per square meter.

	Description		Depth
Gravel:	12.7-19.00 mm		100 mm
	6.35-12.7 mm		75 mm
	3.36-6.35 mm		75 mm
Sand:	1.19-2.38 mm		50 mm
	1.410 mm	100% Accumulated Passing	
	0.841 mm	64-90% Accumulated Passing	
	0.707 mm	42-85% Accumulated Passing	
	0.595 mm	18-50% Accumulated Passing	
	0.500 mm	5-10% Accumulated Passing	
	0.297 mm	0% Accumulated Passing	
		Total	300 mm
Anthracite:	3.360 mm	100% Accumulated Passing	
	1.680 mm	72-90% Accumulated Passing	
	1.410 mm	46-40% Accumulated Passing	
	0.841 mm	5-9% Accumulated Passing	
	0.500 mm	0% Accumulated Passing	
		Total	600 mm

The uniformity coefficient (u.c) of the sand and anthracite as originally specified, would appear not to be less than 1.5. The effective size (e.s.) of the anthracite is greater than 0.85 mm and 0.5 mm for the sand. It would appear

that the anthracite, if these calculations are correct, may be too fine and not very uniform and the sand may be too coarse and also not uniform. This may promote substantial intermixing of media and will not encourage deep bed filtration. Since no recent in-situ analysis of the media exists, it is recommended that an accurate depth and sieve analysis be undertaken for each filter.

Each filter is equipped with a Hach 1720A turbidimeter which measures filter effluent turbidity. Filter influent turbidity is not continuously measured, however, raw water turbidity is continuously measured using a Hach 1720A turbidimeter and periodically verified with a Hach Model 2100A laboratory turbidimeter. Raw water turbidity ranges from 0.27 to 3.6 FTU and filter water turbidity ranges between 0.05 to 0.2 FTU (as can be seen in Table 2.1).

Generally, filter runs of 55 hours are achievable but are usually in the 30-35 h range. The clean bed loss varies with filter throughput. The filters were designed for a filter rate of 18 m/hr, however, the filters operate in the range of 6.8 to 10 m/hr. Filter operation is terminated once the head loss reaches 2.0 m.

The backwashing of filters is performed manually at the filter console. The backwashing sequence allows for variable wash rates based on manual adjustments of duration for low and high rate washes. The plant backwash system is capable of delivering a backwash rate in excess of 70 m/hr at peak flows with normal rates in the order of 45 m/hr.

The washing system consists of two rate control valves, a venturi tube, two backwash pumps and associated control and instrumentation. The set point on the flow controller sets the opening on the first backwash pump control valve. After the first valve has reached its predetermined set point (adjustable), and low rate is achieved, timing and valve position allows the second pump to start. Control of flow is accomplished using the butterfly valve on the pump discharge.

The backwash pumps are of the single suction, mixed flow centrifugal type. The pumps are located at the filter building in the washwater room and have the following characteristics:

Backwash Pump Number	Flow L/s	Head m	Manufacturer	KW
1	1473	12.2	Allis-Chalmers	150
2	1473	12.2	Allis-Chalmers	150

Each filter is equipped with 8-2.75 metre Palmer "S" type surface wash arms.

Operation of the filters is set manually and is overridden automatically by the top 450 mm in the clearwell.

(h) **Clearwell**

The total volume of filtered water storage is made up as follows:

Clearwells	$1504.3m^3$
Filtered Water Conduit	$\underline{901.8m^3}$
Total	$2406.1m^3$

The MOE guidelines recommend treated water storage in the order of 10-20% of treatment capacity. For Bare Point, this would be 9,100-18,200 m^3 based on a nominal plant rating of 90.9 ML/d.

Adequate storage capacity of treated water is desirable in order to allow the filters to operate at constant rates without override conditions or starting and stopping, and to provide adequate water for backwashing purposes.

(i) **High Lift Pumping**

The high lift pumping station is located adjacent to the low lift pumping station and intake area, separate from the filter building. Water is conveyed to the pumping station through approximately 53 metres of box culvert (clearwell conduit with a cross sectional area of $16.91m^2$). Presently there are six high lift pumps located in the high lift area. Two of the six units, Nos. 5 and 6, are located in an area adjacent to the original pumping station that existed prior to construction of the filtration plant.

The data on the high lift pumps is as follows:

High Lift Number	Flow L/s	Head m	KW	Manufacturer
1	316	82.3	298	Allis-Chalmers
2	105	82.3	712	Allis-Chalmers
3	184	82.3	186	Allis-Chalmers
4	211	82.3	224	Allis-Chalmers
5	526	82.3	560	DeLaval
6	526	82.3	560	DeLaval

Pumps 1 to 4 are double stage, single volute, horizontally split case, centrifugal type with side suction and discharge. Pumps 5 and 6 are single stage, double volute, horizontally split case, centrifugal, bottom suction, side discharge. Firm capacity is set at 116.0 ML/d (at 82.3 m head) with the No. 5 or 6 pump out of service and a total capacity of 161.4 ML/d with all six units operating. Provision for an additional pump unit, similar to No. 5 and 6 pump, is available. The station is also fitted with two 200 mm diameter surge relief valves.

(j) **Backwash Disposal**

Backwash water is currently discharged directly to Lake Superior through 137 meters of 900 mm concrete pressure pipe. The outfall terminates with a short riser 900 mm in diameter. The outlet is equipped with a diffuser plate located approximately 30 mm above the top of the riser.

The outfall is located in approximately 3.2 m of water. In order to prevent the Lake water from flowing back into the plant, a 600 mm flap valve has been fitted to the waste water conduit. The conduit connects to the backwash effluent system, and during the backwash cycle a sluice gate (1.2m x 0.9m) opens and the influent sluice gate from the flocculated water channel (0.9m x 0.9m) is closed. This allows backwash water to outlet to the Lake.

It is also noted that the waste water conduit (1.5m x 2.4m) is directly adjacent to the clearwell and is therefore an area of potential cross contamination.

C.3 Chemical Systems

(a) **Disinfectant**

Liquid chlorine is stored in a separate area in the water treatment plant. It is delivered in 900 kg cylinders, and the plant is capable of stocking 12 such containers. The chlorine usage is measured on one scale capable of handling two cylinders.

Three chlorinators and a residual analyzer cabinet are located in a room adjacent to the chlorine storage area.

These units are all manufactured by Wallace and Tiernan and have the following rotameter ratings:

Pre Chlorinator	136 kg/day
Post Chlorinator	45 kg/day
Standby Chlorinator	225 kg/day

Chlorine solution (pre-chlorination) is dosed at the raw water wet well immediately downstream of the travelling screens. It is also fed as a solution (post-chlorination) in the clearwell conduit which connects the filter building to the high lift pump station.

The combined capacity of the chlorinators is 406 kg/d for a total dosage of 2.23 mg/L to 5.07 mg/l for 90.9 ML/d and 40.0 ML/d plant flow rates respectively.

There is one common scale which supports two 900 kg cylinders. These would permit a maximum withdrawal rate of 435 kg/d if larger chlorinators were available.

(b) <u>Coagulant</u>

The aluminum sulphate storage and dosing system consists of:

- two - 22,725 litre PVC lined wood stave holding tanks
- two - BIF metering pumps each rated at 3181 L/d (maximum stroke and speed)

Each pump is equipped with a variable speed controller and manual stroke length adjuster. Each adjustment is linear over a 5:1 range. The metering pumps are automatically paced on raw water flow.

The maximum dosage capacity of the metering pumps is 14 mg/L and 32 mg/L for 90.9 ML/d and 40.0 ML/d plant flows respectively. The application point is in the 900 mm diameter raw discharge header just before it leaves the low lift pumping station.

(c) **Coagulant and Filter Aids**

The coagulant and filter aid storage and dosing system consists of:

- two - 2,272.5 litre fiberglass make-up tanks
- two - 227.25 litre fiberglass storage tanks
- two - BIF metering pumps each rated at 10,908 L/d (maximum stroke and speed) in two sets.

The pumps are automatically paced from raw water flow and equipped with variable speed controllers and manual stroke length adjustment. They dose a 1.0 percent solution of the coagulant aid Percol LT35 at the same point as the aluminum sulphate.

Two additional pumps were originally installed to dose polymer as a filter aid, but these have since been removed and re-used at the Loch Lomond source.

The capacity of the coagulant aid system, assuming a 1.0 percent solution and fifty percent reactivity of the liquid polymer, is 0.6 mg/L to 1.32 mg/L for 90.9 ML/d and 40.0 ML/d flows respectively.

C.4 Photographs

Following is a series of photographs to illustrate major components and chemical feed systems.

In addition, the following drawings are included in the Appendix:

a. Site Plan 493.03-D-16152 - Drawing G2

b. Pumping Stations 493-02-D-16166 - Drawing M13

c. Filter and Flocculation Tanks Plan 493-02-D-16157 - Drawing M4

d. Filter Plant (Sections) 493.02-D-16162 - Drawing M9

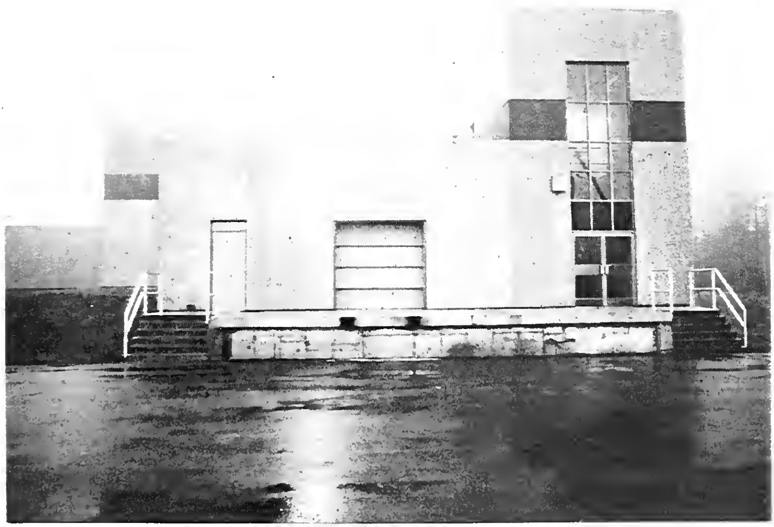
e. Filters - Pipe Gallery Level (Plan and Sections) 493-02-D-16158 Drawing M5

f. Pumping Station (Section) 493.02-D-16168 - Drawing M15

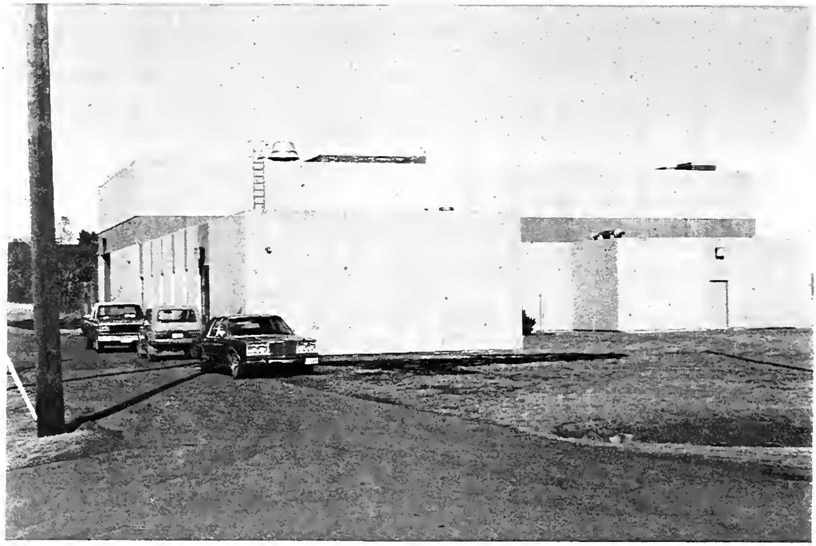
g. Chemical Feed Schematics 493.02-D-16176 - Drawing M23

These are reproductions of original plant drawings prepared by Gore & Storrie Limited.

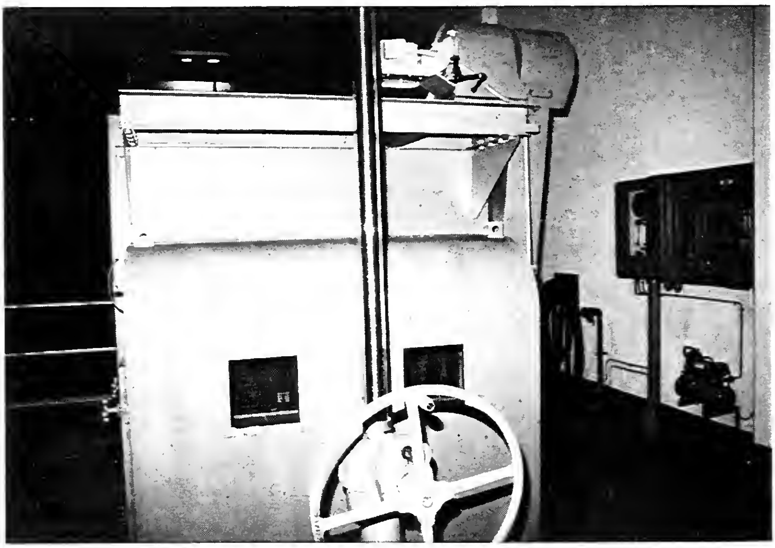
1.Bare Point Water Filtration Plant (Front View)



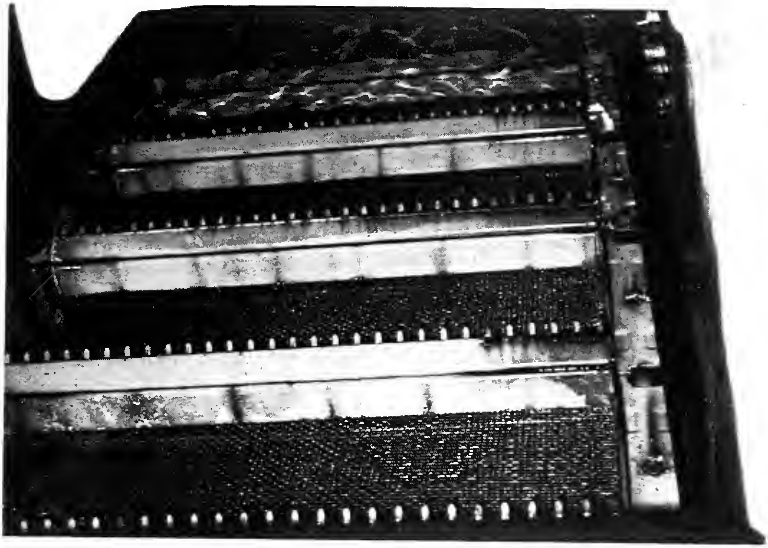
2. Bare Point Filter Building



3.Bare Point Water Filtration Plant (Side View)



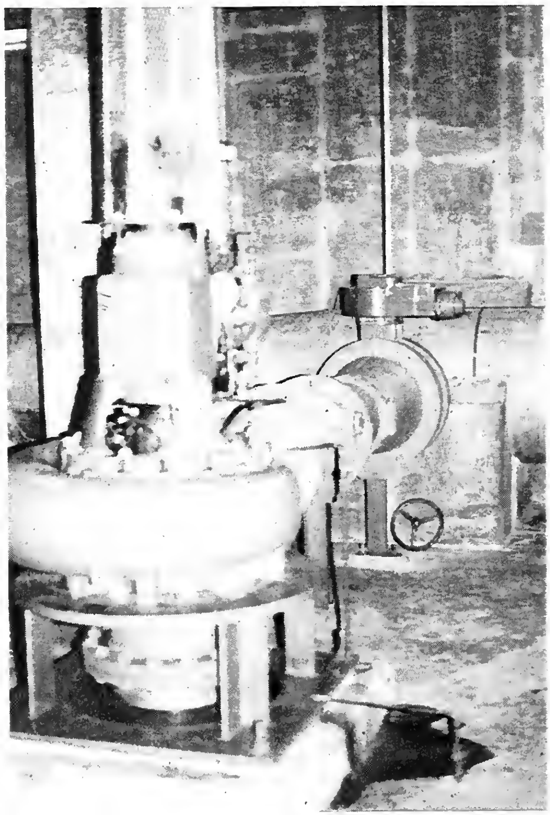
4. Travelling Screens



5. Travelling Screens

6. Raw Water Venturi

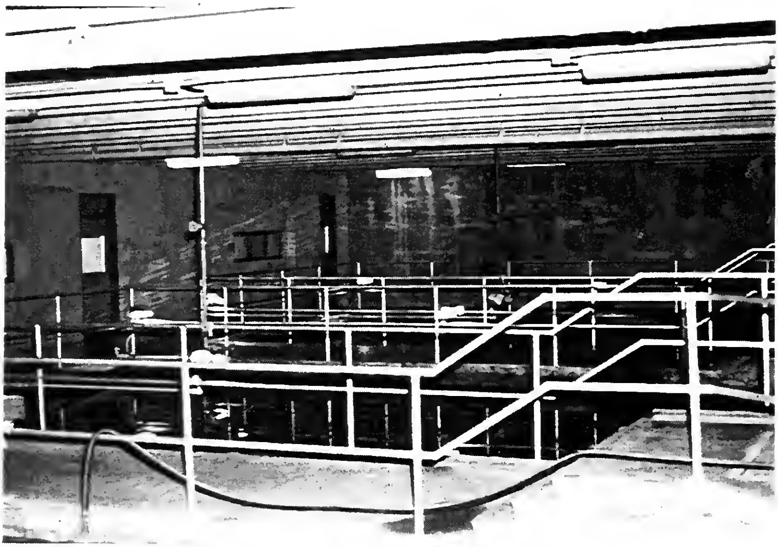
7. Low Lift Pumps



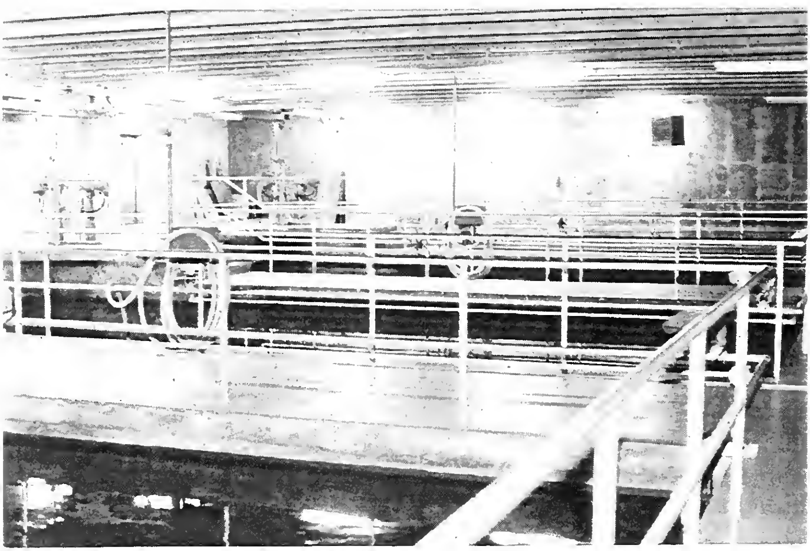
8. Low Lift Pumps

9. Low Lift Pump

10. Filter Piping Gallery

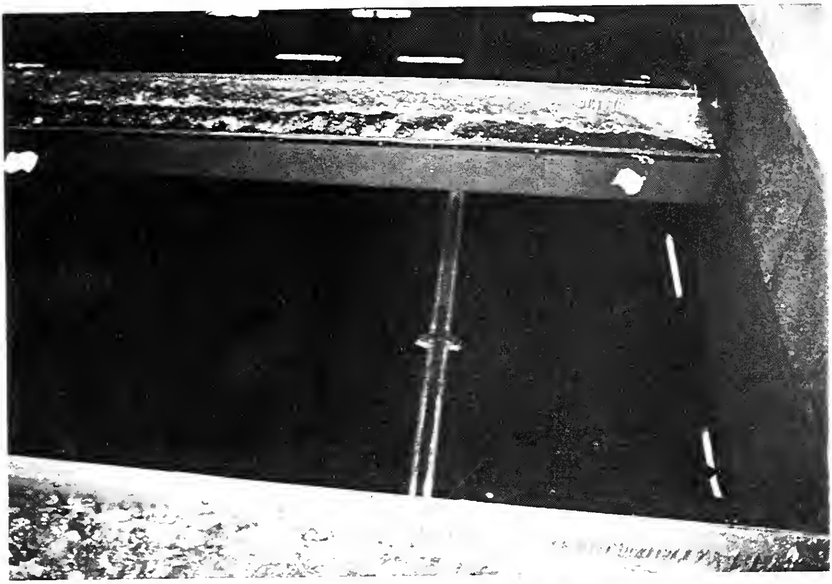


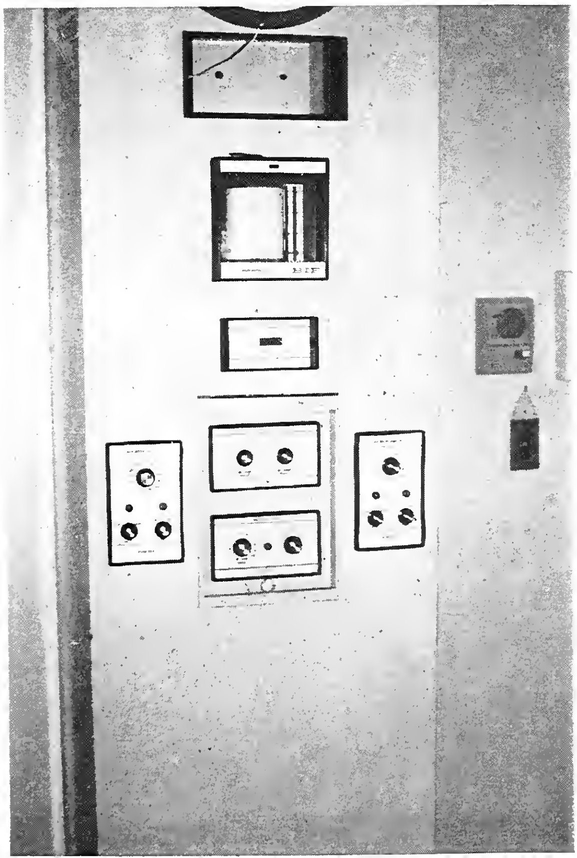
11. Filters



12. Filter Backwashing

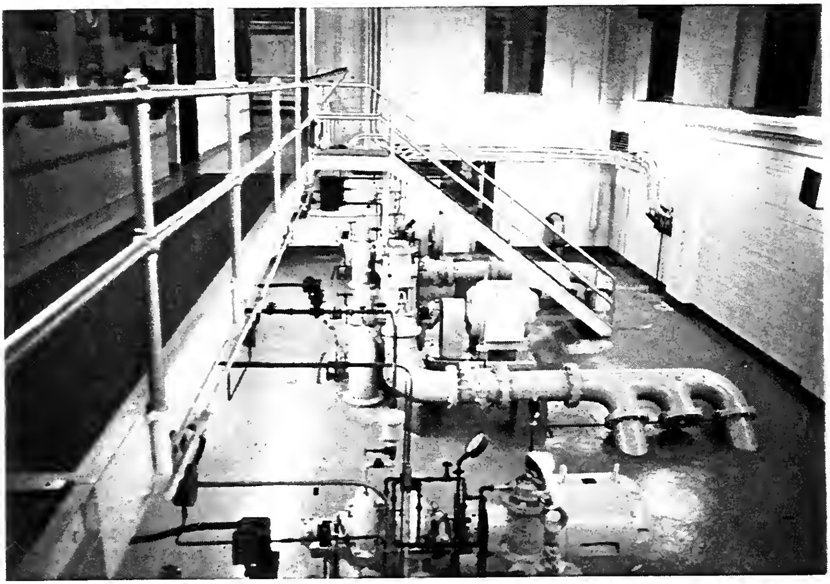
13. Filters

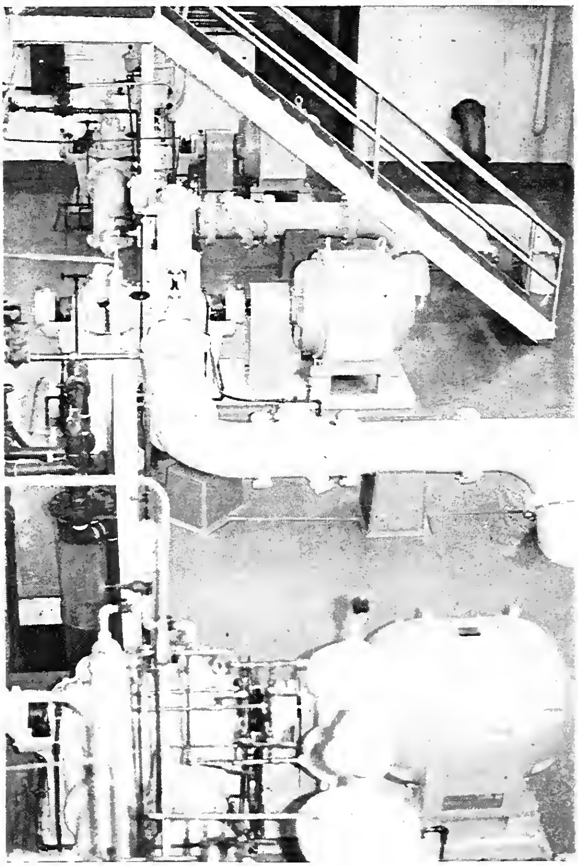




14. Filter Control Console
Master Set

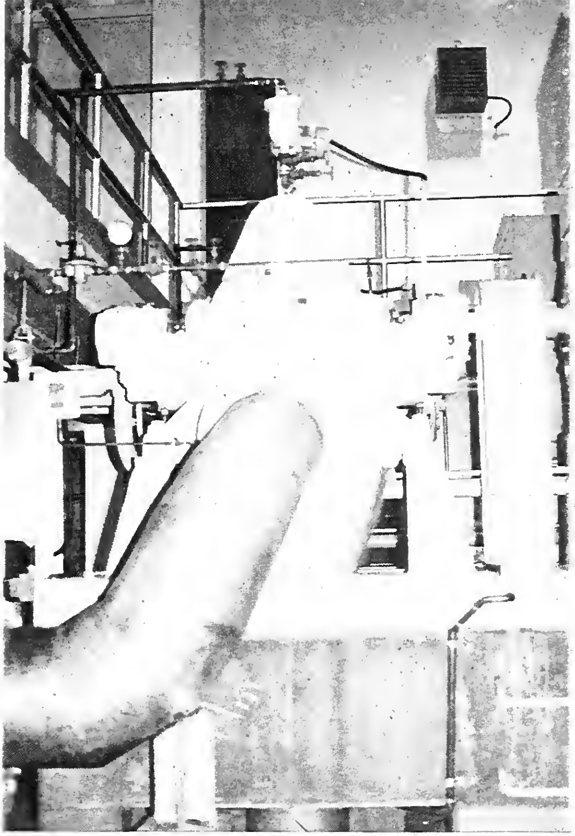
16. High Lift Pumps



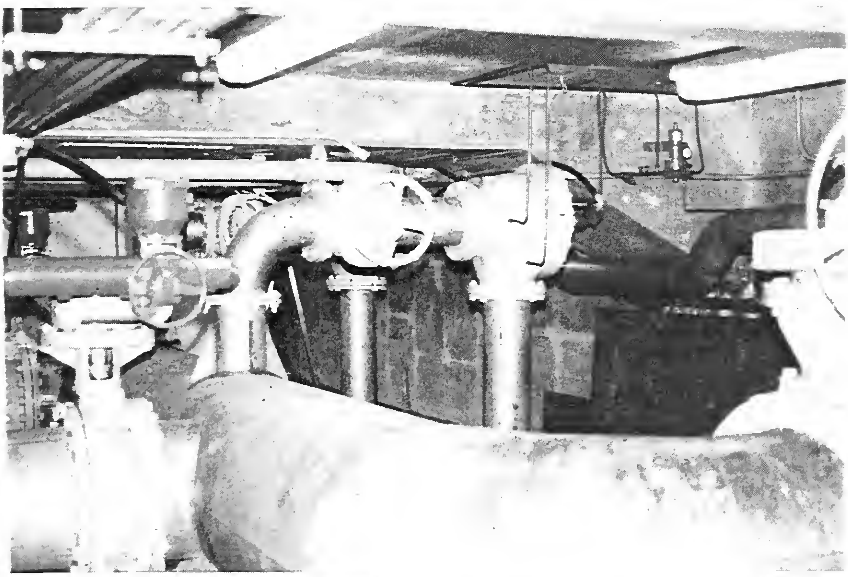


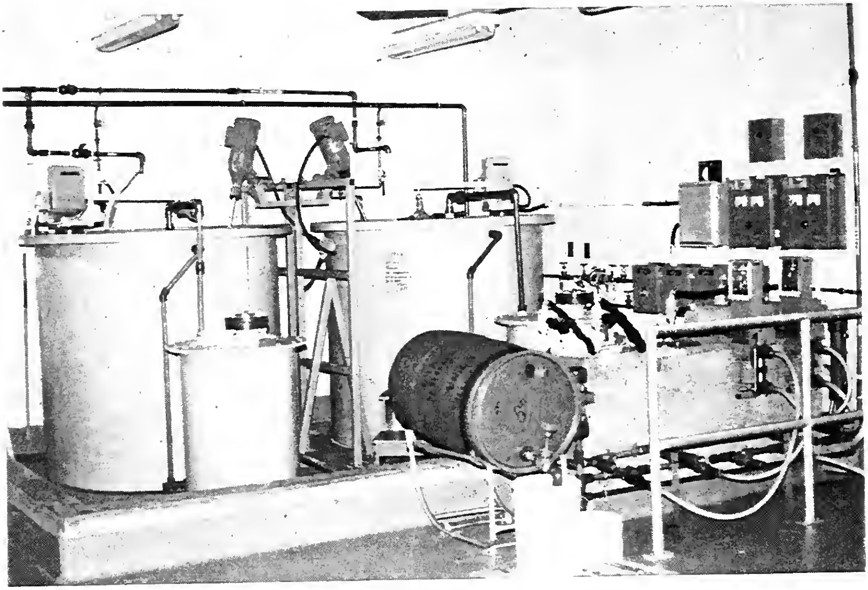
16. High Lift Pumps

17. High Lift Pumps

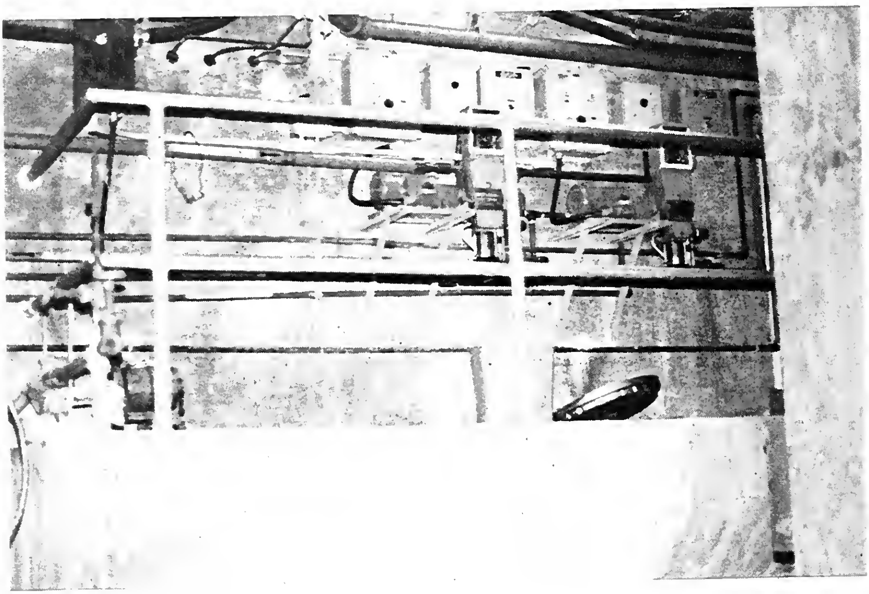


18. Pressure Relief

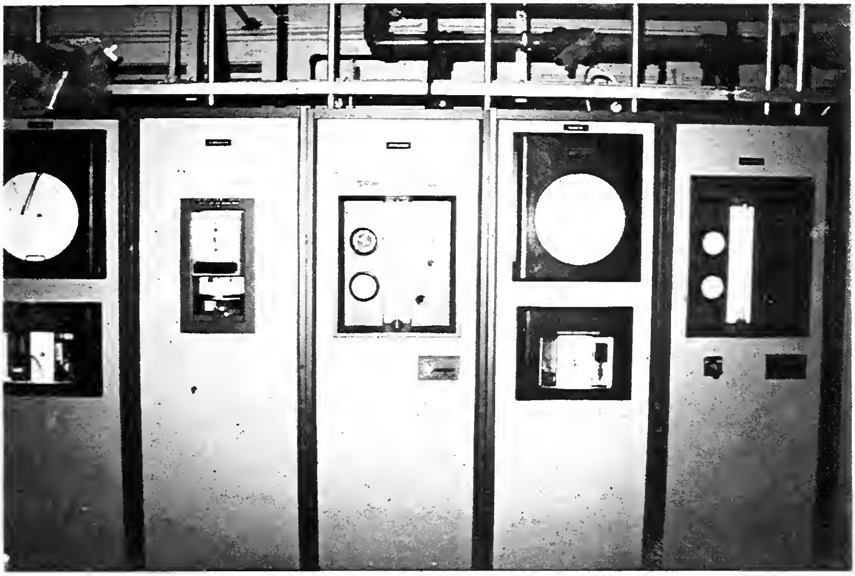




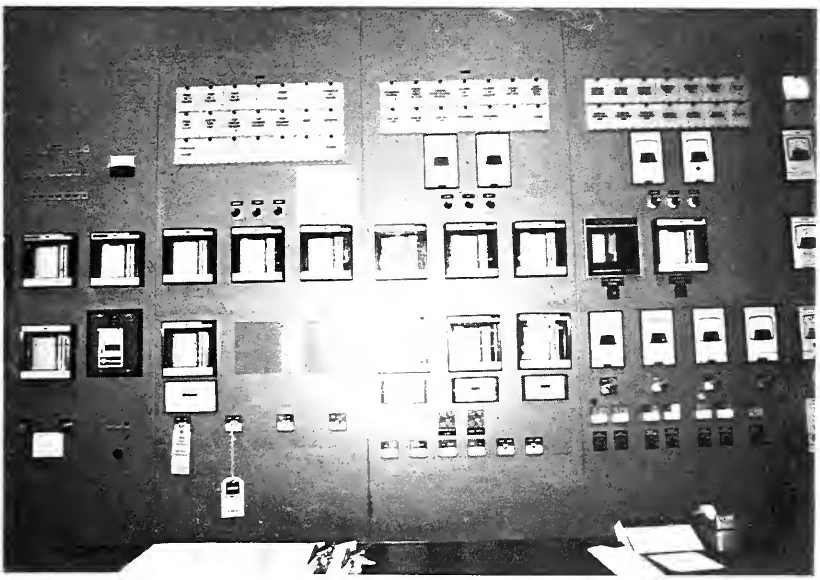
19. Polymer System



20. Aluminum Assist Pump



21. Chlorination System



22. Bare Point Control Panel

23. Flocculation Vessels

24. Flocculation Vessels

SECTION D - PLANT OPERATION

SECTION D PLANT OPERATION

D.1 Description

(a) General

The original plant was constructed in 1913. It consisted of an intake, wet well, high lift pumps and chlorination facilities. Due to occasional complaints of taste and odour, a chlorine dioxide system was installed in 1974.

In 1977 construction of a 90.9 ML/d filtration plant was commenced. The Bare Point Water Treatment Plant became operational in the summer of 1979. Use of the chlorine dioxide system was discontinued at this time.

(b) Flow Control

(i) Raw Water

Three low lift pumps discharge raw water to the flocculation tanks through a 900 mm diameter main. The low lift pumps are controlled as follows:

1. Low lift pumps may be controlled locally from the Motor Control Center which takes precedence over any other mode or remotely, via the operator control station located in the control room.

2. The operator initiates the required low lift pumps based on the demand in the distribution system. The operator sets the master filter rate controller at the filter plant and the water level in the filter inlet channel modulates the butterfly valves on the low lift pump discharges.

3. When the level in the filter inlet channel drops to a predetermined set point or the valve associated with each low lift pump reaches 80 percent of opening, an alarm is triggered.

4. The alarm then signals the operator to turn on another pumping unit or turn on a larger unit and turn off a smaller pump.

5. The valve and pump combinations are under plant operator control and all decisions on the required flow are initiated by this individual.

(ii) Pretreatment

Not all of the flocculation tanks are used. During the summer months two flocculation tanks are used and in the winter months three are used. Each of the flocculation tanks contains three compartments, all of equal size.

The plant operators have experimented with the "spiral" flow flocculators in order to enhance flocculation at lower flows. Experiments such as creating higher entrance velocities in the first stage by throttling the inlet sluice gate provided no apparent improvement. Other methods such as keeping one bank of these vessels out of service lead to other problems such as freezing and inoperability of the motorized sluice gate (due to the gate operators being exposed to the elements). Operations staff have reported the need to remove sediment from the flocculation tanks, which would mean that the velocity through the final stages is insufficient to keep floc in suspension.

(iii) Filtration

All three filters are operated at all times except during periods of backwashing and maintenance. The flow rate through the filters is controlled as follows:

1. The flow rate control system is based on the concept of constant rate filtration using a venturi and associated modulating filter rate control valve.

2. Coarse adjustment of plant flow rate is made by operator selection of low lift pump combinations and the modulating valve on each low lift

discharge. Fine adjustment of filter flow rate is by the master rate setter that establishes a common set point for each filter.

3. As the clearwell nears 450 mm from the top water level, the clearwell level automatically overrides the master rate set point to minimize the frequency of shutdown.

4. All controller outputs (for each filter) can be adjusted separately by by-passing the master rate setter.

(iv) Plant Discharge

The high lift pumps discharge treated water to the distribution system. The pumps draw water from the filtered water conduit. This conduit is connected to the clearwell which is located directly under the filters. The pumps are controlled as follows:

1. All high lift pumps may be controlled locally from the motor control centre which takes precedence over any other mode. High lift pumps numbers 5 and 6 can be remotely controlled from the control room.

2. The pumps are stopped and started manually, based on maintaining the Duke Street reservoir level between 0.6 and 1.8 metres from top water level.

(c) <u>Filter Backwashing</u>

The criteria used to initiate a filter backwash is time, headloss or turbidity of filtered water. The limit for headloss is 2.0m and for turbidity is 1.0 NTU. The filters are however, normally washed on time, generally in the 30-35 hour range. The backwashing procedure is as follows:

- Close the influent valve

- Drain the filter to low level through filtrate valve
- Close the filter valve
- Open the drain valve
- Open the surface wash valve
- Start the backwash pump (low wash)
- Open the backwash flow control valve until limit is reached (low wash achieved). Operate for 5-8 minutes
- Start the second backwash pump (high rate)
- Close surface wash valve
- Open the backwash flow control valve until media is suspended to bottom of wash troughs (leave for 10 minutes)
- Stop high rate backwash pump subject to clarity of water from filters (i.e. media is visible)
- Close first backwash control valve (allow backwash water to fill filter to top of troughs)
- Stop backwash pump (total wash time 20-25 minutes)
- Open filter influent valve
- Open filtrate valve
- Master rate setter takes over

During this operation the master rate setter does not reproportion the flow to the remaining operational filters, however this can be done by taking manual control of each filter and setting the individual filter rate control to the desired output.

Depending on the flow through the plant, the decision to take manual control is made. The preceding sequence is manually performed at the filter console associated with each filter.

The filter console serves the following purposes:

- valve and equipment status indication
- operator interface of backwash program

The filters are not allowed to rest after a backwash and are ramped on-line in 1.5 to 2.0 minutes.

The filtered water from each filter is continuously monitored by one of the three Hach 1720A turbidimeters. The filter effluent turbidity is continuously recorded on a strip chart recorder located in the control room and alarmed when the turbidity exceeds 1.0 FTU.

Normal plant operating practice is to monitor the raw water turbidity and the filter effluent for turbidity and aluminum residual. Grab samples are also taken every two hours from these areas and analyzed in the plant laboratory by a Hach 2100 A turbidimeter.

(d) **<u>Chemical Dosage Control</u>**

Aluminum sulphate, chlorine and liquid polymer solution are added year round.

(i) Alum

Dosages vary between 1.8 mg/L and 14.9 mg/L with a yearly average of 5.0 mg/L to 6.0 mg/L. Raw water quality changes are fairly gradual and relatively small, so that the alum dosage adjustments are also small. A turbidity profile is taken once every 2 hours and in this manner variations in the coagulant dosage can be made in order to provide effective flocculation.

Jar tests are not carried out at this plant since the results would not be of any benefit in operating a direct filtration plant. The plant does have its own pilot filter plant which can be operated in order to deal with unusual conditions. The pilot plant was used extensively in a pilot testing program by Proctor & Redfern Limited in 1985. The results of the pilot plant study are discussed in Section E of this Report.

The alum metering pump stroke adjustment is manually set and the pump speed is flow paced from the raw water venturi meter. The alum usage is measured daily, at midnight, by measuring the level drop through the sight glass on the 22,725 litre storage vessels. This is not a reliable method of measurement. Based on the use of two tanks, a variation in tank level of 1 mm translates to a volume of aluminum sulphate of 14 litres. At an average flow of 40 ML/d and an average dosage of 6.0 mg/L, the daily drop in level would be 12.5 mm.

(ii) Chlorine

The pre-chlorine dosages are set up on a compound loop system and are set to maintain a free chlorine residual of 1.3-1.4 mg/L. The post-chlorine dosage is also based on a compound loop system to maintain a free chlorine residual in the order of 1.2 mg/L to 1.4 mg/L.

Pre- and post-chlorine feeds are taken from the same chlorine cylinder. Chlorine residuals are measured by a Wallace and Tiernan amperometric titrator.

Free chlorine residuals of raw water are measured in the low lift pumping area from the 900 mm diameter raw water line prior to leaving the building while the treated water residuals are measured in a 100 mm diameter line just downstream of the high lift pumps. The sample lines run up to the laboratory and flow continuously. The raw and treated water chlorine residuals are measured continuously and grab samples are analyzed every 2 hours.

Daily confirmation of total chlorine used is calculated by weight loss from the active cylinder and is read every 24 hours. The split between pre-chlorination and post chlorination can only be determined by the ratio of the setpoints.

(iii) Liquid Polymer (Coagulant Aid)

Liquid cationic polymer (Percol LT35) is used as a coagulant aid on a continual basis. The present system has a capacity of dosing 10,908 L/d of one percent solution or 109.08 L/d of liquid polymer on a 100 percent active basis. However, Percol LT35 is only 50 percent reactive and hence on an active basis the metering pump can deliver 54.54 L/d. Therefore at a plant rating of 90.9 ML/d, the maximum dosage would be in the order of 0.6 mg/L. This can be doubled by utilizing the standby metering pump if required.

In order to provide an accurate basis for measurement of the amount of polymer solution used, a 227 litre fiberglass day tank is employed. One percent solution is made and stored in two 2272.5 litre fiberglass tanks.

The polyelectrolyte solution is dosed at the same point that the aluminum sulphate is added, and was originally also dosed in the filter influent channel through a pipe diffuser which straddles the channel opening.

Plant staff have stated that dosing polymer in the filter influent channel was ineffective in producing better quality effluent from the filters and was discontinued. This facility was originally installed due to a concern over the presence of asbestos in the raw water. This did not, however, materialize.

The dosage and use of the Percol LT35 was verified in pilot plant studies undertaken by Proctor & Redfern Limited in 1985. The polymer dosage in this pilot work ranged from 0.05 mg/L to 0.34 mg/L with normal dosage between 0.22 and 0.28 mg/L.

(e) <u>Quality Control Testing</u>

The following table lists pertinent information on the sample systems in use at the Bare Point Plant. All sample lines terminate in the plant laboratory.

Source	Length m	Size mm	Flow L/min	Velocity m/s	Travel Time min.
Raw Water	53	20	22	1.2	0.73
Pre Flocculated	39	20	*	-	-
Flocculated	115	20	*	-	-
Filtered	97	20	22	1.2	1.35
Treated	34	20	*	-	-

All sample lines are P.V.C.

* not normally operated but can be run at approximately 25 L/min.

In-Plant Monitoring

The following Table gives a list of tests performed on a continuous basis at the Bare Point Plant.

Continuous Monitoring

Parameter	Equipment	Location
Temperature		Continuously sampled from intake well ahead of traveling screen
pH	Beckman Model 941	Continuously sampled from intake well ahead of screens
Chlorine Residual (free)	Wallace & Tiernan	Raw water from 900 mm raw watermain
	Wallace & Tiernan	Finished water from plant discharge
Turbidity	Hach 1720A	Raw water-continuously sampled from intake well ahead of traveling screen

Filter effluent (No.1, 2 & 3)
Continuous on outlet from each filter

Finished water continuously sampled from clearwater conduit prior to High Lift.

The following Table gives a list of tests performed on a batch basis at the Bare Point Plant.

Test	**Treatment Stage**	**Testing Frequency**	**Reporting Frequency**	**Testing Instrument**
Turbidity	raw	every 2 hours	every 2 hours	Hach 2100A
	treated	every 2 hours	every 2 hours	Hach 2100A
Chlorine Residual	raw	every 2 hours	every 2 hours	W&T Titrator
	treated	every 2 hours	every 2 hours	W&T Titrator
Hardness	raw	weekly	weekly	Hach DR2000 Spectrometer
		monthly	monthly	Test performed by MOE
Alkalinity	raw	monthly	monthly	Test performed by MOE
Temperature		daily	daily	
pH		every 2 hours	every 2 hours	Hach pH meter
Bacteriological	raw	weekly	weekly	Tests performed by MOE
Phytoplankton	raw	weekly	weekly	

Chlorinated Organics	raw	monthly	monthly	Test performed by MOE
Iron	raw	bi-monthly	bi-monthly	Tests performed by MOE
Conductivity	raw	bi-monthly	b-monthly	
Chlorides	raw	bi-monthly	bi-monthly	
Colour	raw	bi-monthly	bi-monthly	

Note: Turbidity, chlorine residual and pH are also monitored & indicated on a continuous basis as shown in the preceding Table.

D.2 Operation and Process Concerns

The following operation and process concerns have been noted at this plant.

(a) Rapid Mixing

The existing system is intended to provide an area of high energy for coagulation of aluminum sulphate and polymer with particles in the raw water. It falls under the category of "jet" or "in line" mixing. Studies of this principle in the early seventies are well documented in the Journals of the American Water Works Association. Most of the principles of introducing primary coagulants into a receiving stream have been through the use of multiple orifices. It was recommended by Kawamura (J.AWWA 1976) that G values in the order of 700-1000 sec^{-1} and a mixing time of 1.0 sec should be used for design.

Jet or in line type mixers theoretically provide a number of advantages over mechanical mixers namely:

- simple
- inexpensive
- easy to operate
- efficient rapid mixing

- does not create significant headloss

The jet type system of in line mixing at Bare Point is not a multiorifice type and alum and polymer are injected in the same chemical line prior to entering the 900 mm raw watermain. Although the injection line extends inside the raw watermain a distance of 0.3 metres, the cross flow velocity within the raw watermain varies with the amount of raw water being conveyed to the filters.

Based on the studies undertaken (but not officially documented) by the City, it has also been noted that if the alum assist pump is turned off or malfunctions, there is a notable deterioration in the quality of water in the flocculators.

Jet mixing is best obtained by introducing the chemical in a horizontal fashion upstream of the flocculators. It is also recommended that the outlet be multiported.

Studies should therefore be undertaken to better document the jet mixing that is accomplished by the current system and ways to enhance the system if necessary. Alternatively, a new mixing system should be considered.

(b) <u>**Flocculation Mixing**</u>

The type of mixing provided at the plant is dependent on the flow rate.

Experiments have been undertaken with the "spiral" flow flocculators by the plant operators in order to enhance flocculation at lower flows. Operations staff have reported build-up of sediment from the flocculation tanks which indicates that the velocity through the final stages is insufficient to keep the floc in suspension.

It is also noted that the baffles installed within the flocculators are constructed of wood which allows an ideal harbour for algae and bacteria (such as klebsiella).

(c) **Filters**

One major aspect of filter flexibility, design and operation is the treatment capacity that is available when a filter is out of service for repair or backwashing. With a total of 3 filters at the Bare Point Plant, the removal of one filter for backwashing reduces the plant capacity by 33 percent.

This is especially important during maximum day or even during higher than average sustained consumption periods since the available clearwell storage is limited for supply of treated water. Furthermore, the size of the backwash pumping facilities (pumps, valves and piping) has needed to be larger for larger filters.

For a plant rated at 90.9 ML/d, it would be preferable to have in the order of 4 to 6 filters to provide flexibility and security of operation at all times.

Of major importance is the size and consistency of filter media which currently exists at the plant. The operations staff have experimented with operating the filters at their design rating of 18m/hr. Due to high headloss and poor effluent turbidity, however, this rate cannot be sustained for more than 3-4 hours. From the original media specifications it would appear that the media is not very uniform and it has a low effective size. This may be the main reason why high headloss occurs during high rate operations. Since the plant was commissioned over ten years ago, no sieve analysis has been undertaken to determine the present uniformity coefficient and effective size of the media.

It is also noted that there is a substantial difference between measured raw and treated water flows. Table 1 in the Appendix shows that this discrepancy amounts to between 10 and 15 percent. While there is evidently leakage in the drain sluice gates, it is also noted that there is a significant amount of backwashing required due to the short filter runs previously noted. It has been reported that in August of 1984, there were over 200 filter backwashes required. This represent an average for 2.2 backwashes per filter per day.

(d) **Discharge and Intake Limitations**

Due to hydraulic limitations of the capacity of the treated water transmission system, the City staff has completed installing a new 900 mm discharge line from the high lift pumping station. While this new discharge main will reduce the treated water limitation, the capacity of the intake will remain a limitation at 68.2 ML/d until the proposed new intake is completed in late 1991.

(e) **Solids Handling**

There is no removal of solids prior to discharging waste water to the lake. Based on raw water turbidity and alum dosage, the volume of sludge discharged back to the lake is in the range of 30-60 m^3/d.

SECTION E - PLANT PERFORMANCE (PARTICULATE REMOVAL)

SECTION E PLANT PERFORMANCE (PARTICULATE REMOVAL)

E.1 Turbidity Removal

(a) General

Of all the characteristics which give an indication of poor water quality, turbidity is considered as one of the most important. It has been shown in many studies that the particulates responsible for turbidity can harbour bacteria and other hazardous materials and shield them from disinfection. It is for this reason that the Ontario drinking water objectives have a maximum acceptable concentration of 1 NTU for turbidity, while lower level are preferable. Seasonal variations in the turbidity of a water supply impose requirements on a water treatment plant design and operation in order for a plant to achieve all year round effluent of low turbidity.

The raw water from Lake Superior is treated at the Bare Point Water Treatment Plant. As previously discussed in detail in Sections C and D, this water is treated by prechlorination, flocculation, filtration and post chlorination prior to discharge into the distribution system.

A variation in the turbidity levels of the raw water has been recorded over the range of 0.2 to 3.6 FTU. Although these values are relatively low in comparison to some surface water sources in Ontario, they are high enough to warrant filtration as part of the treatment process of this water.

Figures 3a to 3c display the average turbidities in a graphic form. In each case, the lowest average turbidity is recorded in March and a gradual rise occurs to reach peak turbidity in October or November when lake turnover is experienced. Included in these Figures are the treated water turbidity values, which show that the average monthly turbidity is in range of 0.1 FTU. Closer examination of the maxima and minima of the monthly values in Table 2.0 in the Appendix show the operating range to be from 0.02 to 0.45 FTU.

Throughout the year, alum and liquid cationic polymer (Percol LT35) are used as the coagulants, with the dosage of the coagulants varying with the turbidity of the raw water.

(b) <u>Sampling System</u>

The turbidity of the water in the plant is monitored both continuously and by grab samples at different locations. Hach Model 1720A turbidimeters continuously monitor the raw water, effluent from filters 1, 2 and 3 and the finished water from the clearwater conduit prior to the high lift pumps. The analytical readings are monitored in the control room, where the information received is continuously monitored. Grab samples are obtained every two hours from the raw, and treated water and are analyzed at the Bare Point Laboratory using a Hach 2100A Turbidimeter.

(c) <u>Particulate Removal Efficiency</u>

The Bare Point Plant generally treats water of low turbidity, with the exception of the lake turnover period in the Fall. The level of treatment provided by the plant ensures that water with low turbidity enters the distribution system at all times. (See Table 3 and Figures 3a, 3b and 3c at the end of this Section).

E.2 Treatability Testing

(a) <u>Pilot Plant Study</u>

In April 1985, Proctor and Redfern undertook treatability studies using the pilot plant located at the Bare Point facility. The details of the report can be read in its entirety in 'A Study of Alternative Water Supplies' - The Corporation of the City of Thunder Bay (Proctor and Redfern, 1985).

The project consisted of using the City's pilot plant (shown schematically in Figure 4) primarily to evaluate rapid mix flocculation times and filter rates. The objectives of the study were to:

- Assess maximum filtration rates using the existing plant media

- Optimize flocculation time for the direct filtration process and evaluate rapid mixing of the coagulant.

- Optimize the dosages of chemicals required to give best colour and turbidity removal in the Lake Superior water.

- Evaluate and optimize filter aid and dosage.

- Evaluate plant performance using 10 degrees C raw water.

The results of this study concluded that:

- Runs in excess of 24 hours can be achieved at a filter rate of 18m/hr (6 IGPM/sq.ft).

- A minimum of 25 minutes flocculation was required to achieve the desired results at a raw water temperature of 5 degrees C. However, at a temperature of 10 degrees C, 15 minutes flocculation time was adequate to achieve the same results.

- Best results as measured by turbidity removal and filter run length were obtained using 4 mg/L Alum plus 0.3 mg/L of Allied Colloids Percol LT35 as coagulants.

Following these studies, the above dosages of Alum and Percol LT35 were adopted for the plant operation and are currently working satisfactorily. However, the plant itself still cannot achieve filter rates of 18m/hr for a period of 24 hours. (This factor alone would suggest that further studies should be

Figure 3a

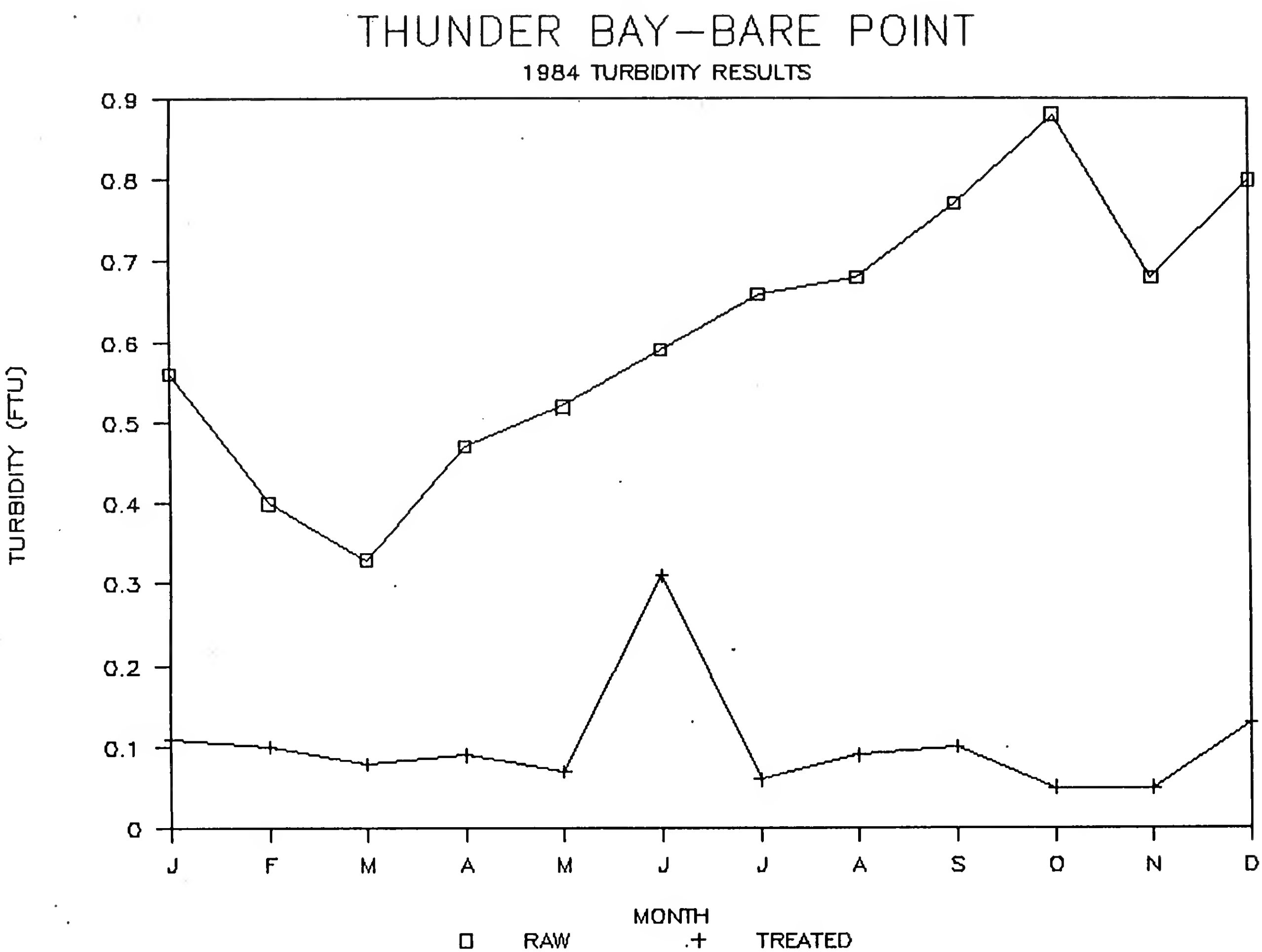

THUNDER BAY—BARE POINT
1984 TURBIDITY RESULTS
TURBIDITY (FTU)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
J
F
M
A
M
J
J
A
S
O
N
D
MONTH
RAW
TREATED

Figure 3b

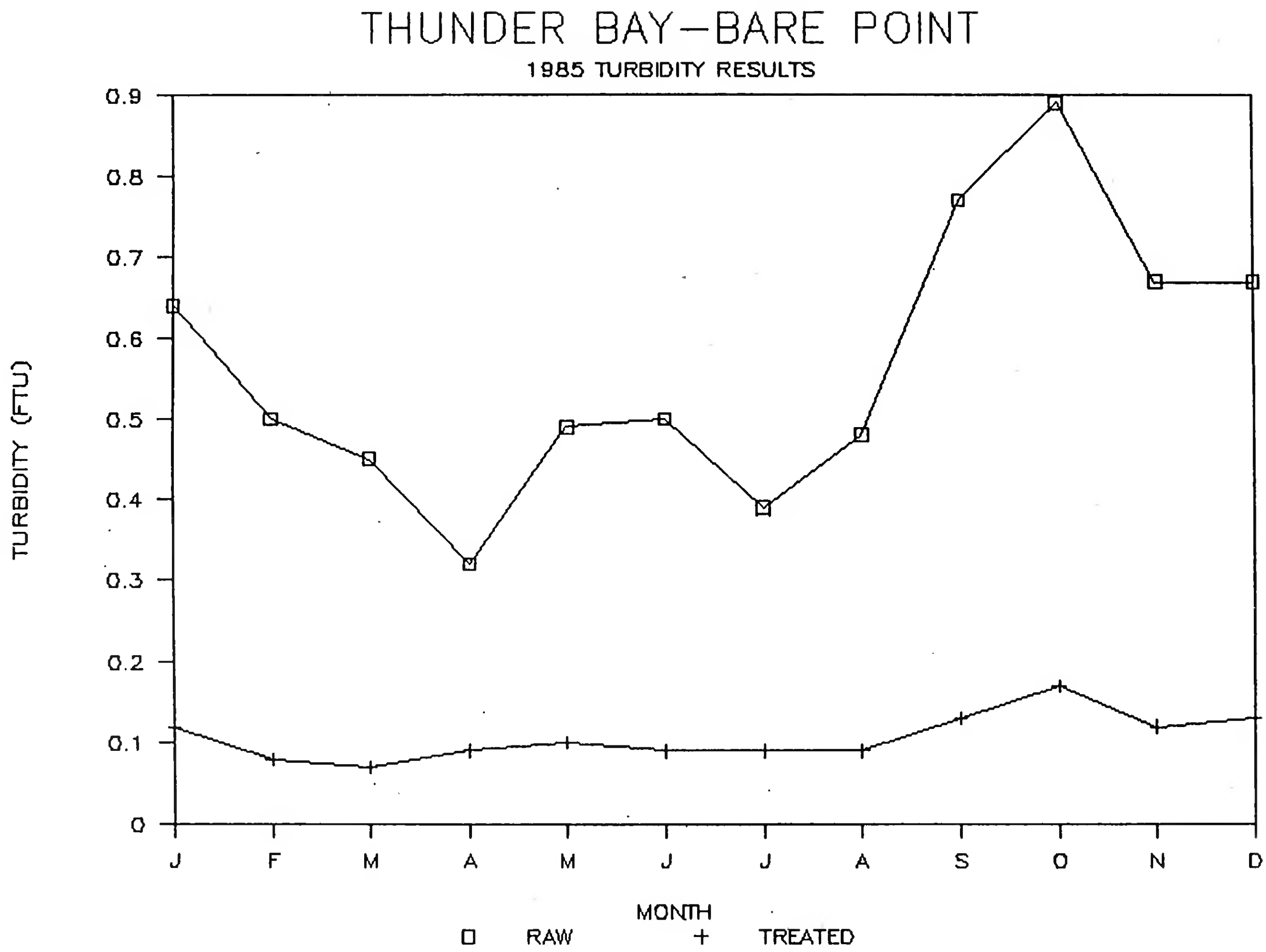
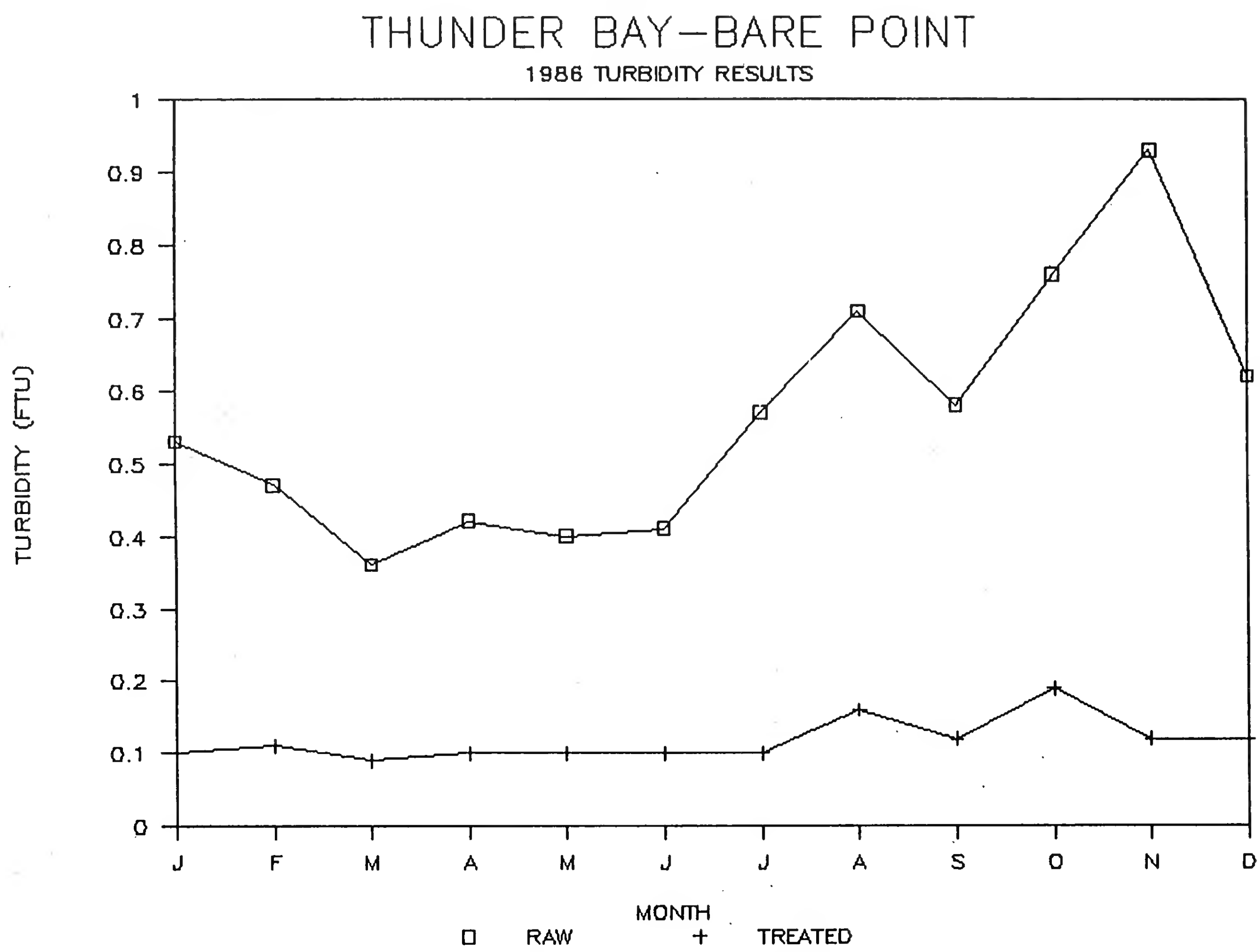

THUNDER BAY—BARE POINT
1985 TURBIDITY RESULTS
TURBIDITY (FTU)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
J
F
M
A
M
J
J
A
S
O
N
D
MONTH
RAW
TREATED

Figure 3c


THUNDER BAY—BARE POINT
1986 TURBIDITY RESULTS
TURBIDITY (FTU)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
J
F
M
A
M
J
J
A
S
O
N
D
MONTH
RAW
TREATED

undertaken on the filters in order to evaluate the uniformity coefficient and effective size of the media).

E.3 Optimum Removal Studies

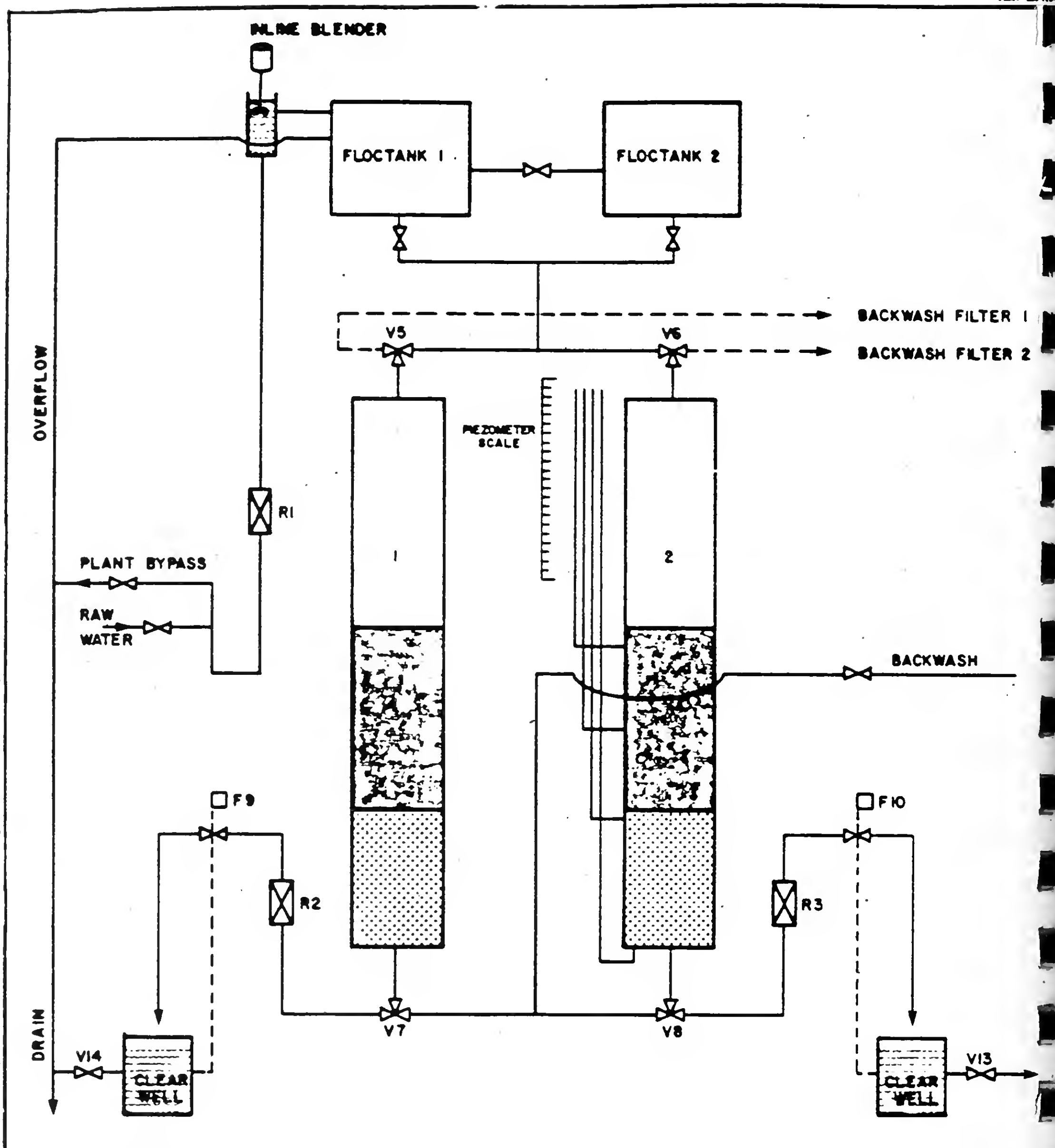
(a) Flocculation and Mixing

The existing method of mixing which provides an area for high energy coagulation of the aluminum sulphate and Percol LT35 in the raw water is a type of jet mixing. This is 'psuedo jet mixing', due to its lack of multiorifice diffusers and injection of alum and polymer in the same chemical line into the raw water flow stream. (See Section D.2 (a)). It would appear that this mixing is adequate but is also dependent upon flow. It is our recommendation that studies be carried out to determine the effects of varying jet velocity with variation in raw water flow rates and to investigate the use of multiple orifices in the jet mixing system.

It is also recommended that the use of in-line blenders be considered for improved coagulation.

At the present time, alum and polymer are added simultaneously. Studies should be carried out to determine if better results would be obtained by adding the polymer further downstream of the alum addition point. However, there is a practical difficulty in carrying out this study since it would require the dosage point to be located in a buried pipeline.

When the plant is operated at its design rating, it may be desirable to examine the use of alternative chemicals such as polyaluminum chloride as a coagulant, in order to decrease sludge volume (if backwash settling or treatment is implemented), to permit a more effective coagulation process under low temperature conditions and to reduce residual aluminum levels should these become a problem. The use of alternative chemicals such as polyaluminum chloride could also be investigated in order to optimize the efficiency of the particulate removal.



R1, R2, R3 - ROTAMETER FLOW INDICATOR
V5, V6, V7, V8 - THREE WAY VALVES
F9, F10 - FLOAT OPERATED VALVES
V13, V14 - FOR CONSTANT RATE FILTRATION

REVISIONS		
APPROVED BY	SCHEMATIC ARRANGEMENT OF MODIFIED PILOT PLANT	The Proctor & Redfern Group Consulting Engineers and Planners Toronto Thunder Bay
		FIGURE No. 4

The type of flocculation provided at the plant is dependent upon the flow rate to control the level of mixing. The plant operators have experimented with various conditions to enhance the flocculation at lower levels. Methods have included creating higher entrance velocities in the first stage by throttling the inlet sluice gate - which provided no improvement to water quality.

Other methods such as keeping one bank of these vessels "off line" provided other problems such as freezing and hence inoperability of the motorized sluice gate (due to the gate operators being exposed to the elements). Operations have reported removal of sediment from the flocculation which would mean that velocity through the final stages was insufficient to keep the floc in suspension.

If alum were added at in-line blenders installed in the low lift pump discharge piping, then it would be possible to add the polymer at the existing dosage location, thus effectively improving alum coagulation and separating the chemical dosage points.

(b) **Filtration**

Of major importance is the size and consistency of filter media which currently exists at the plant. The operations staff have experimented with operating the filters at their design rating of 18 m/hr, however, due to high headloss and poor effluent turbidity this rate cannot be sustained for more than 3 to 4 hours. From the media specifications, it is evident that the media is not very uniform and it has a low effective size. This may be the main reason why high headloss is being experienced during high flows. Since the plant was commissioned over ten years ago, no sieve analysis has been undertaken to determine the present uniformity coefficient and effective size.

It is the opinion of Proctor & Redfern that each of these inadequacies should be investigated.

(c) <u>Relative Merits of Optimum Processes</u>

In order of importance it is proposed that the following strategies for maximum particulate removal be investigated.

1. Examine the current state of the filter media.

2. Examine the effect of rapid mixing on chemical coagulation and particulate removal.

3. Examine the use of polyaluminum chloride as a coagulant.

4. Examine flocculation under varying flow conditions.

Table 3

Turbidity Levels of Treated Water from Bare Point Plant

(1983-1986)

Month	**Turbidity (FTU)**		
	Max.	**Min.**	**Avg.**
January	0.18	0.08	0.11
February	0.26	0.08	0.11
March	0.22	0.07	0.11
April	0.16	0.08	0.09
May	0.14	0.07	0.09
June	0.39	0.06	0.17
July	0.12	0.06	0.09
August	0.24	0.08	0.12
September	0.27	0.08	0.12
October	0.37	0.07	0.14
November	0.14	0.07	0.10
December	0.26	0.09	0.13

SECTION F - PLANT PERFORMANCE (DISINFECTION)

SECTION F PLANT PERFORMANCE (DISINFECTION)

F.I Disinfection Practices

(a) General

Disinfection is defined as a treatment that destroys harmful microorganisms. Currently available methods include chemical and non-chemical means of treatment. Chemicals that are capable of destroying bacteria are usually powerful interactive compounds which can combine with organic compounds present in the water. Of the chemicals applied for water disinfection, chlorine is the most widely used. However, research on chlorine has shown that by-products are formed when chlorine is used on water containing elevated dissolved organic carbon and/or high levels of colour. Some of these by-products can be hazardous to long term health and it is therefore important to minimize the formation of these products. This means that water treatment plants must maintain the proper disinfection of the water with the minimum formation of chlorinated by-products.

At the Bare Point Plant, chlorination is carried out in the intake well (pre-chlorination) and in the clearwell conduit upstream of the high lift pumping station (post-chlorination). The plant objective is to maintain 1.3 mg/L of free chlorine residual on the top of the filters and to produce water with 1.3 mg/L of free chlorine residual as it leaves the plant. The average chlorine residual in the treated water is 1.2 to 1.4 mg/L.

(b) Measurement System

The free chlorine residual at the Bare Point Plant is analyzed with a Wallace and Tiernan chlorine residual analyzer. The chlorine residual is monitored continuously at two locations; after the pre-chlorination point in the raw water intake and in the finished water leaving the plant. The free chlorine residual of the treated water is also analyzed every 2 hours using an amperometric titrator in the plant laboratory. With this equipment and the frequency of

analysis of the chlorine residuals, it is felt that the results are accurate and reliable.

F.2 Disinfection Efficiency

The efficiency of chlorine as a disinfectant is dependent upon the formation of hypochlorous acid in solution. The formation of hypochlorous acid in water is dependent upon several factors; pH, temperature, residence time, and chlorine demand. As each of these parameters increase, the efficiency of the hypochlorous acid in solution decreases. For water at the Bare Point Treatment Plant, the pH, temperature and residence times are within acceptable limits for chlorine to act as an efficient disinfectant. Table 4 shows the presence of fecal coliforms at various levels in the raw water from Lake Superior. The treated water indicates that neither fecal nor total coliforms were present. These results, in combination with the free chlorine residual of 1.3 mg/L in the treated water and the bacterial analysis shown in the following Table 4, indicates that the plant is adequately disinfecting the water.

Table 4

Bacteriological Testing - Bare Point

1983-1985

	Total Coliform No. per 100 ml		Fecal Coliform No. per 100 ml		Fecal Streptococcus No. per 100 ml	
	Raw	**Treated**	**Raw**	**Treated**	**Raw**	**Treated**
January	9-<51.2	abs	<2-<2.5	abs	<2-2	abs
February	<4-4	abs	<2-2	abs	<2-2	abs
March	<4-<16	abs	<2-2	abs	<2-2	abs
April	<4	abs	<1-<2	abs	<2	abs
May	<4-<24	abs	<2	abs	<2	abs
June	<4-157	abs	<2-<4.5	abs	<2-<3.5	abs
July	<6-208.8	abs	<2-<3	abs	<2-<9	abs
August	<7-106	abs	<2-<4	abs	<2-<3	abs
September	<13-88	abs	<2	abs	<2-<4	abs
October	<44-<87	abs	<2-<4	abs	<2-<4	abs
November	14-35	abs	<2-<3.5	abs	<2	abs
December	<14-21.3	abs	<2	abs	<2	abs

Information obtained from Thunder Bay Bare Point Plant data. The figures are all obtained from monthly averages.

F.3 Chlorinated By-product Formation

(a) Current Requirements

Chlorinated by-products are produced in virtually every system where chlorine is used as the method of disinfection. The formation of these products is due to the reaction of chlorine with organic compounds present in the water. This

can give rise to a variety of halogenated materials which can be placed into several categories. One of these categories is trihalomethanes (THM). The Ontario Ministry of the Environment criteria for THM's in drinking water is 350 ug/L and assessments of the THM levels present in treatment plants are based upon this value.

The Plant at Bare Point treats raw water with average dissolved organic carbon levels of 8 mg/L. This would indicate that there is some potential for formation of THMs.

On average, 88 ug/L of trihalomethanes are formed at this plant as shown in Table 4.0 in the Appendix. This result is based upon Drinking Water Surveillance Programme figures and falls within the MOE guideline of 350 mg/L.

(b) <u>Attainable Levels</u>

It could be said that if no free chlorine was used, the potential for THM formation would be zero. This would be true, for instance, if pre-ozonation and disinfection using chloramination were carried out. When chlorine is used for disinfection of the incoming water, some THM formation is inevitable. Levels below 350 ug/L are, however, attainable and achieved at this plant.

In our opinion, the chlorine feed system and the operating policy for disinfection are adequate. A separate method of weighing pre- and post-chlorine feeds would be a worthwhile modification since it would permit a direct assessment of the individual dosages.

SECTION G - SHORT AND LONG TERM MODIFICATIONS

SECTION G SHORT AND LONG TERM MODIFICATIONS

G.1 Description

This section is an assessment of the modifications which could increase the efficiency of operation of this plant.

G.2 Chemical Mixing

The existing Chemical "Jet Mixing" system at the Bare Point plant enhances the coagulation stage of the direct filtration treatment process. Staff have reported deleterious effects if the "alum assist" pump is turned off or malfunctions. We recommend that additional testing on the jet mixing system be continued in order to evaluate its effect on coagulation. The cost of this operation should be minimal if carried out by plant staff.

Alternatively, coagulant addition at in-line blenders on the low lift pump discharges should be considered. The cost of this change would be approximately $300,000.

G.3 Alum Usage

At the present moment the method of calculating alum dosage is based on level measurement in the two 22,725 litre holding tanks. Such a method can cause significant errors. We recommend that small calibrated day tanks be installed on the suction side of the alum metering pumps for more accurate measurement. The cost of implementing this improvement is relatively minor.

G.4 Polymer Application Point

Polymer (Percol LT35) is applied in the same chemical line as alum. The effects of combining alum and polymer prior to injection into the raw water should be reviewed in order to obtain optimum performance from both chemicals. We recommend that a separate polymer dosage point be installed

further downstream. This should be carried out in conjunction with the recommendations in G.2

The cost of this recommendation may be significant if a point downstream of the existing is required, since this would involve a dosage point in a buried pipeline outside the existing plant buildings.

If in-line blenders on the low lift pump discharges are used for coagulant addition, polymer could be added at the existing combined coagulant/polymer location.

G.5 Coagulant Aids

Following the optimization of the mixing of alum and the currently used polymer, the next stage would be to examine the use of alternative coagulants such as polyaluminum chloride (PACL) and coagulant aids.

We recommend that the City perform pilot studies to prescreen the optimum coagulants and coagulant aids. A plant scale pilot programme could then be conducted for various seasons during a one year period on the most promising coagulant combination.

The cost of this study would be in the region of \$10,000 - \$15,000.

G.6 Flocculators

The energy in the flocculation tank is proportional to the actual flow rate and cannot be mechanically varied. Isolation of portions of the floc tanks and throttling of the sluice gates have resulted in operational difficulties with no apparent improvement to treated water quality.

We recommend that operation of the flocculation tanks be compared on a plant scale basis for both summer and winter flows. We also recommend that alternative methods of varying the energy of mixing be investigated. The cost

of the former recommendation is minimal. The cost of the latter recommendation could exceed $500,000 due to the need to introduce flocculation equipment into the existing totally covered tanks.

G.7 Flocculator Baffles

The flocculator baffles are made from wood which is an ideal material to harbour bacteria such as klebsiella. Replacement with stainless steel baffles would remove this potential.

The cost of this operation however, could exceed $50,000, and since no klebsiella or related problems currently exist, it may not be reasonable to replace the baffles at this time.

G.8 Filter Media Characteristics

The characteristics of media can change with time. The gradation of the filter media is currently unknown, and it is suspected that it does not meet the design criteria.

We recommend that the City of Thunder Bay carry out a sieve analysis on each filter as soon as possible. We also recommend that the depth of filter media be measured annually from several reference points related to the filter operating floor.

The cost of replacing all the media would be approximately $150,000.

G.9 Chlorine Use Verification

Pre- and post-chlorine are presently fed from the same cylinder; it is therefore only possible to verify the total chlorine use by recording weight loss from the single cylinder.

We recommend that the City install a separate weigh scale to allow individual weighing of pre- and post-chlorine feeds.

This would cost in the order of $20,000 to $25,000.

G.10 Treated Water Discrepancies

Table 1.0 in the Appendix shows that there is upwards of a 15 percent discrepancy between raw and treated water flows. Possible explanations are leaking drain valves or excessive backwash water required due to the number of washes performed. It is recommended that the City undertake a thorough review of this discrepancy. The cost of this investigation would be minimal if the City undertook the search. The cost of the remedial work is unknown at the time and therefore cannot be estimated.

G.11 Record Keeping

The plant record information from the three-year study period has been catalogued as shown in the Appendix. This provides the necessary information in a concise form and it would be prudent for the plant staff to adopt this format for ongoing record keeping, and to provide ready access to this information.

The cost would be minimal using a personal computer with a spreadsheet software package.

G.12 Loch Lomond Supply

If it is decided Loch Lomond should no longer be used as a source of water for the City of Thunder Bay, then a significant expansion of the Bare Point Plant facilities will be required. Operating experience would indicate that this is less costly than building a new plant at Loch Lomond to treat that supply.

The required works would include a new intake and expansion of pretreatment and filtration facilities, as well as raw and high lift pumping and chemical equipment. This was the subject of the report "A Study on Alternative Water Supplies" - The Corporation of the City of Thunder Bay by Proctor and Redfern, 1985.

A decision should be made regarding the long term future of Loch Lomond.

APPENDIX A - TABLES

TABLE 1

WATER PLANT OPTIMIZATION STUDY
"PLANT FLOWS"

TABLE 1.0: FLOWS (ML/d)

BARE POINT

MOE WPOS PROTOCOL

		1986			1985			1984			1983		
		MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG
JAN	R	45.58	37.55	40.42	50.00	35.00	40.93	41.95	30.00	37.74	36.77	29.45	33.96
	T	43.02	29.18	35.28	45.70	24.50	37.13	37.85	27.07	33.02	32.84	23.87	29.12
FEB	R	45.25	39.04	41.44	44.00	30.00	37.80	39.03	27.40	36.46	36.54	28.70	35.22
	T	40.46	31.87	36.99	41.50	30.50	34.95	35.27	23.40	31.95	34.87	25.94	30.85
MAR	R	44.71	38.16	41.43	50.00	24.00	40.32	39.27	28.19	37.14	35.10	31.47	34.57
	T	41.66	31.13	37.54	48.50	24.20	34.74	36.19	24.81	32.53	31.55	25.37	30.20
APR	R	46.47	38.17	41.43	52.00	33.00	41.39	39.93	27.53	37.35	43.21	30.79	34.39
	T	43.92	31.65	37.88	47.00	23.50	36.34	36.32	24.21	32.81	30.87	24.45	30.36
MAY	R	47.34	39.53	43.46	50.00	26.00	41.31	39.74	31.97	38.41	37.83	31.22	35.48
	T	42.73	32.90	38.83	49.00	22.00	35.12	35.60	28.29	33.47	35.06	25.21	31.04
JUN	R	49.57	40.23	44.64	48.00	26.00	41.87	45.63	27.37	39.98	41.29	32.67	38.01
	T	44.93	32.14	39.47	46.50	24.00	36.51	43.56	25.26	35.97	38.39	28.89	33.69
JUL	R	53.50	40.97	47.44	56.00	26.00	43.42	45.83	28.58	40.57	49.92	36.77	46.06
	T	49.16	31.87	41.37	48.60	22.50	38.13	42.48	25.23	37.12	46.52	31.49	39.88
AUG	R	53.77	42.94	47.98	54.00	26.00	42.74	44.29	34.77	42.68	48.93	35.97	44.55
	T	47.52	27.76	38.72	48.00	22.00	38.06	41.27	31.88	37.63	43.55	30.98	38.07
SEP	R	48.37	36.58	43.50	53.00	23.00	42.07	41.00	32.00	39.13	42.70	33.77	40.22
	T	43.59	26.89	37.82	48.70	22.70	37.22	37.95	29.58	35.36	39.83	29.17	34.85
OCT	R	46.26	39.06	41.17	46.00	28.00	40.36	39.50	31.50	38.90	38.33	33.00	35.73
	T	40.65	29.53	36.42	46.00	23.50	35.78	36.75	26.79	33.99	34.31	27.61	31.43
NOV	R	45.83	37.85	41.56	44.00	28.00	39.77	42.00	36.00	39.96	37.83	33.38	35.21
	T	40.60	30.31	36.39	48.00	24.00	35.13	36.96	29.46	33.91	32.09	26.71	30.78
DEC	R	44.77	39.23	41.18	49.00	20.00	40.42	40.50	38.00	39.32	36.66	31.31	35.88
	T	38.74	31.43	36.09	48.00	24.00	35.34	39.33	30.76	34.86	32.27	27.04	31.36

TABLE 2

WATER PLANT OPTIMIZATION STUDY "PARTICULATE REMOVAL SUMMARY"

**

TABLE 2.0: PARTICULATE REMOVAL SUMMARY-BARE POINT

MOE WPOS PROTOCOL

			1986			1985			1984		
			MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG
JAN	TURBIDITY (FTU)	R	0.700	0.440	0.530	1.080	0.520	0.640	1.100	0.420	0.560
		T	0.140	0.090	0.100	0.220	0.060	0.120	0.190	0.090	0.110
	Prime Coagulant (mg/L)		8.010	2.820	3.990	11.900	7.250	9.310	9.070	6.350	7.260
	Coagulant Aid (mg/L)		0.270	0.120	0.230	0.340	0.150	0.210	0.210	0.130	0.170
	Filter Aid (mg/L)										
	Metal Res. (Al) (mg/L)	R	0.003	0.000	0.002	0.050	0.005	0.033	0.007	0.003	0.005
		T	0.011	0.000	0.007	0.080	0.008	0.037	0.011	0.008	0.030
	pH	R	7.710	7.490	7.620	7.820	7.510	7.650	7.700	7.354	7.560
		T	7.300	7.020	7.160	7.200	7.070	7.120	7.350	7.030	7.160
	Temperature (C)		5.000	4.500	4.890	5.000	4.000	4.600	5.000	4.000	4.840
FEB	TURBIDITY (FTU)	R	0.710	0.340	0.470	0.580	0.400	0.500	0.750	0.310	0.400
		T	0.180	0.080	0.110	0.120	0.050	0.080	0.480	0.120	0.130
	Prime Coagulant (mg/L)		8.270	3.680	5.330	9.840	3.050	7.030	7.710	5.930	6.720
	Coagulant Aid (mg/L)		0.290	0.130	0.240	0.280	0.210	0.240	0.170	0.150	0.160
	Filter Aid (mg/L)										
	Metal Res. (Al) (mg/L)	R	0.003	0.003	0.003	0.003	0.003	0.003	0.011	0.003	0.007
		T	0.011	0.003	0.007	0.011	0.008	0.009	0.011	0.010	0.010
	pH	R	7.780	7.120	7.700	7.800	7.400	7.670	7.900	7.400	7.670
		T	7.340	7.120	7.200	7.300	7.050	7.170	7.280	6.950	7.150
	Temperature (C)		5.000	5.000	5.000	5.000	5.000	5.000	5.000	4.500	4.690
MAR	TURBIDITY (FTU)	R	0.410	0.280	0.360	0.630	0.370	0.450	0.480	0.270	0.330
		T	0.120	0.070	0.090	0.100	0.050	0.070	0.430	0.090	0.168
	Prime Coagulant (mg/L)		4.200	1.800	3.160	12.390	5.750	7.600	7.800	5.950	6.710
	Coagulant Aid (mg/L)		0.280	0.240	0.260	0.260	0.150	0.200	0.180	0.150	0.160
	Filter Aid (mg/L)										
	Metal Res. (Al) (mg/L)	R	0.003	0.003	0.003	0.003	0.003	0.003	0.007	0.003	0.005
		T	0.008	0.008	0.011	0.008	0.008	0.009	0.012	0.011	0.012
	pH	R	7.800	7.580	7.700	7.830	7.470	7.710	7.890	7.730	7.840
		T	7.350	7.120	7.220	7.480	7.030	7.180	7.350	7.230	7.270
	Temperature (C)		5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000
APR	TURBIDITY (FTU)	R	0.950	0.290	0.420	0.760	0.250	0.320	0.850	0.320	0.470
		T	0.170	0.090	0.100	0.110	0.070	0.090	0.190	0.080	0.090
	Prime Coagulant (mg/L)		6.600	2.280	3.540	9.090	6.190	7.200	10.170	5.780	7.250
	Coagulant Aid (mg/L)		0.260	0.230	0.250	0.220	0.150	0.180	0.200	0.160	0.180
	Filter Aid (mg/L)										
	Metal Res. (Al) (mg/L)	R	0.003	0.003	0.003	0.003	0.003	0.003	0.005	0.003	0.004
		T	0.011	0.008	0.009	0.011	0.008	0.009	0.011	0.008	0.009
	pH	R	7.680	7.270	7.340	7.790	7.560	7.610	7.900	7.760	7.860
		T	7.250	6.720	7.140	7.300	7.060	7.180	7.320	7.110	7.250
	Temperature (C)		6.000	5.000	5.400	6.000	5.000	5.300	7.000	5.000	5.500

MOE WPOS PROTOCOL

TABLE 2.0 (cont'd)

				1986			1985			1984		
				MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG
MAY	TURBIDITY (FTU)		R	0.550	0.360	0.400	0.760	0.390	0.490	0.830	0.400	0.520
			T	0.110	0.080	0.100	0.340	0.080	0.100	0.200	0.040	0.070
	Prime Coagulant	(mg/L)		7.270	2.470	5.340	10.210	6.020	7.680	12.440	6.950	9.380
	Coagulant Aid	(mg/L)		0.300	0.240	0.270	0.230	0.170	0.180	0.230	0.170	0.190
	Filter Aid	(mg/L)										
	Metal Res. (Al)	(mg/L)	R	0.003	0.003	0.003	0.003	0.003	0.003	0.005	0.005	0.005
			T	0.011	0.005	0.008	0.011	0.008	0.009	0.011	0.008	0.010
	pH		R	7.810	6.950	7.590	7.760	7.600	7.670	7.840	7.680	7.760
			T	7.300	6.770	7.130	7.290	7.090	7.140	7.290	6.700	7.160
	Temperature	(C)		9.000	6.000	7.580	11.000	6.000	7.420	9.000	6.500	7.770
JUN	TURBIDITY (FTU)		R	0.690	0.420	0.512	0.700	0.430	0.500	0.900	0.430	0.590
			T	0.180	0.080	0.100	0.130	0.080	0.090	0.850	0.025	0.310
	Prime Coagulant	(mg/L)		8.990	4.490	5.970	11.150	6.820	8.240	14.850	7.490	10.400
	Coagulant Aid	(mg/L)		0.300	0.230	0.270	0.210	0.160	0.180	0.210	0.110	0.160
	Filter Aid	(mg/L)										
	Metal Res. (Al)	(mg/L)	R	0.003	0.003	0.003	0.003	0.003	0.003	-	-	- -
			T	0.008	0.005	0.007	0.011	0.008	0.009	-	-	-
	pH		R	7.840	7.600	7.710	7.820	7.580	7.730	-	-	7.800
			T	7.300	7.100	7.230	7.250	7.070	7.150	-	-	7.160
	Temperature	(C)		13.000	9.000	10.400	12.000	9.000	9.930	13.000	9.000	10.440
JUL	TURBIDITY (FTU)		R	0.710	0.450	0.570	0.870	0.390	0.570	0.840	0.470	0.660
			T	0.130	0.080	0.100	0.160	0.090	0.100	0.080	0.025	0.060
	Prime Coagulant	(mg/L)		8.400	2.650	5.610	9.880	1.350	6.290	12.210	8.790	10.660
	Coagulant Aid	(mg/L)		0.300	0.180	0.270	0.280	0.160	0.170	0.220	0.060	0.140
	Filter Aid	(mg/L)										
	Metal Res. (Al)	(mg/L)	R	0.003	0.003	0.003	0.003	0.003	0.003	0.005	0.005	0.005
			T	0.011	0.008	0.009	0.011	0.008	0.100	-	-	-
	pH		R	7.920	7.500	7.770	7.900	7.490	7.720	7.880	7.400	7.790
			T	7.350	7.110	7.260	7.340	7.000	7.140	7.200	7.010	7.110
	Temperature	(C)		16.000	10.000	12.290	14.000	9.000	11.370	15.000	9.000	11.750
AUG	TURBIDITY (FTU)		R	1.100	0.570	0.710	0.720	0.480	0.550	0.920	0.480	0.680
			T	0.390	0.090	0.160	0.190	0.090	0.110	0.140	0.060	0.090
	Prime Coagulant	(mg/L)		9.220	3.130	4.790	7.420	3.320	5.520	12.460	7.750	10.160
	Coagulant Aid	(mg/L)		0.310	0.110	0.270	0.250	0.190	0.220	0.290	0.070	0.080
	Filter Aid	(mg/L)										
	Metal Res. (Al)	(mg/L)	R	0.003	0.003	0.003	0.003	0.003	0.003	0.011	0.003	0.005
			T	0.008	0.008	0.008	0.008	0.008	0.008	0.011	0.005	0.008
	pH		R	8.140	7.170	7.800	7.890	7.600	7.730	8.000	7.500	7.800
			T	7.400	7.110	7.200	7.480	7.080	7.270	7.180	7.030	7.110
	Temperature	(C)		16.000	10.000	12.690	18.000	9.000	13.370	18.000	8.000	13.190

MOE WPOS PROTOCOL

TABLE 2.0 (cont'd)

			1986			1985			1984		
			MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG
SEP	TURBIDITY (FTU)	R	0.750	0.430	0.580	2.100	0.550	0.770	1.040	0.620	0.770
		T	0.290	0.070	0.120	0.380	0.080	0.130	0.130	0.080	0.100
	Prime Coagulant (mg/L)		6.310	2.610	4.010	6.780	4.240	5.370	12.590	8.400	10.080
	Coagulant Aid (mg/L)		0.320	0.240	0.280	0.300	0.250	0.270	0.200	0.050	0.110
	Filter Aid (mg/L)										
	Metal Res. (Al) (mg/L)	R	0.012	0.003	0.007	0.003	0.003	0.003	0.008	0.003	0.004
		T	0.008	0.005	0.007	0.011	0.008	0.027	0.008	0.002	0.007
	pH	R	7.970	7.000	7.730	7.990	7.550	7.690	7.970	7.620	7.800
		T	7.450	7.080	7.240	7.320	7.080	7.200	7.290	6.940	7.090
	Temperature (C)		15.000	9.000	12.030	16.000	9.000	13.900	16.000	8.000	10.190
OCT	TURBIDITY (FTU)	R	1.010	0.520	0.760	1.430	0.660	0.890	2.500	0.480	0.880
		T	0.450	0.090	0.190	0.526	0.100	0.170	0.130	0.020	0.050
	Prime Coagulant (mg/L)		7.510	2.570	4.760	10.100	5.290	6.580	14.900	7.950	9.880
	Coagulant Aid (mg/L)		0.340	0.220	0.250	0.300	0.200	0.280	0.960	0.070	0.170
	Filter Aid (mg/L)										
	Metal Res. (Al) (mg/L)	R	0.010	0.003	0.004	0.003	0.003	0.003	0.008	0.003	0.004
		T	0.020	0.008	0.010	0.008	0.006	0.008	0.008	0.007	0.007
	pH	R	7.800	7.450	7.640	7.800	7.590	7.700	7.910	7.680	7.770
		T	7.430	7.060	7.200	7.300	7.000	7.190	7.200	7.000	7.130
	Temperature (C)		12.000	10.048	12.030	12.000	10.000	10.440	12.000	10.000	10.970
NOV	TURBIDITY (FTU)	R	3.600	0.590	0.930	1.240	0.610	0.670	0.850	0.550	0.680
		T	0.190	0.080	0.120	0.180	0.090	0.120	0.060	0.030	0.050
	Prime Coagulant (mg/L)		8.000	4.720	5.760	7.870	4.300	5.430	12.220	6.060	9.840
	Coagulant Aid (mg/L)		0.260	0.220	0.240	0.260	0.210	0.250	0.200	0.080	0.130
	Filter Aid (mg/L)										
	Metal Res. (Al) (mg/L)	R	0.012	0.005	0.009	0.003	0.003	0.003	0.080	0.030	0.005
		T	0.020	0.015	0.018	0.011	0.008	0.009	0.012	0.008	0.010
	pH	R	7.840	7.510	7.730	7.800	7.480	7.690	7.800	7.030	7.750
		T	7.330	7.080	7.240	7.400	7.170	7.260	7.250	7.030	7.100
	Temperature (C)		8.000	3.000	6.020	10.000	0.600	8.270	10.000	7.000	7.780
DEC	TURBIDITY (FTU)	R	0.820	0.500	0.620	0.880	0.560	0.670	1.200	0.680	0.800
		T	0.370	0.080	0.120	0.240	0.090	0.130	0.170	0.110	0.130
	Prime Coagulant (mg/L)		8.390	4.470	5.870	7.450	4.770	5.640	10.470	6.350	8.160
	Coagulant Aid (mg/L)		0.270	0.200	0.240	0.290	0.240	0.260	0.190	0.090	0.140
	Filter Aid (mg/L)										
	Metal Res. (Al) (mg/L)	R	0.012	0.010	0.011	0.003	0.003	0.003	0.005	0.003	0.004
		T	0.020	0.020	0.020	0.011	0.011	0.011	0.080	0.008	0.009
	pH	R	7.840	7.560	7.690	7.930	7.670	7.700	7.830	7.580	7.750
		T	7.340	7.100	7.320	7.390	7.180	7.240	7.400	7.080	7.170
	Temperature (C)		5.000	3.000	4.110	6.000	5.000	5.650	7.500	4.500	5.760

TABLE 2.1: PARTICULATE REMOVAL PROFILE (JAN/84)-BARE POINT
MOE WPOS PROTOCOL

DATE	TURBIDITY (NTU)				COAGULANT	COAG. AID	FILTER AID	METAL RES. (Al) (mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.	mg/L	mg/L	mg/L	RAW	TREATED	RAW	TREATED	(C)
1	-	-	-	-	8.87	0.17	-	-	-	-	-	5.0
2	-	-	-	-	7.63	0.19	-	-	-	-	-	5.0
3	1.10	-	-	0.16	7.54	0.20	-	-	-	7.70	7.10	4.5
4	0.94	-	-	0.13	8.78	0.18	-	-	-	7.65	7.21	4.0
5	0.88	-	-	0.22	7.46	0.19	-	-	-	7.60	7.18	4.0
6	0.93	-	-	0.21	6.90	0.21	-	0.003	0.008	7.62	7.20	4.5
7	-	-	-	-	7.49	0.19	-	-	-	-	-	4.0
8	-	-	-	-	7.09	0.20	-	-	-	-	-	5.0
9	0.54	-	-	0.13	7.40	0.19	-	-	-	7.70	7.30	5.0
10	0.68	-	-	0.16	8.07	0.20	-	-	-	7.65	7.20	4.5
11	0.72	-	-	0.21	7.35	0.20	-	-	-	7.75	7.33	5.0
12	0.84	-	-	0.14	7.21	0.20	-	0.007	0.011	7.55	7.15	5.0
13	0.68	-	-	0.15	5.75	0.20	-	-	-	7.63	7.20	5.0
14	-	-	-	-	6.39	0.18	-	-	-	-	-	5.0
15	-	-	-	-	6.80	0.20	-	-	-	-	-	5.0

DATE	TURBIDITY (NTU)				COAGULANT	COAG. AID	FILTER AID	METAL RES. (Al) (mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.	mg/L	mg/L	mg/L	RAW	TREATED	RAW	TREATED	(C)
16	0.67	-	-	0.16	8.50	0.15	-	-	-	7.60	7.30	5.0
17	0.50	-	-	0.15	6.35	0.13	-	-	-	7.61	7.33	5.0
18	0.42	-	-	0.11	6.87	0.19	-	-	-	7.62	7.15	5.0
19	0.49	-	-	0.09	7.17	0.14	-	0.003	-	7.70	7.35	5.0
20	0.57	-	-	0.22	6.49	0.15	-	-	-	7.65	7.43	5.0
21	-	-	-	-	6.97	0.15	-	-	-	-	-	5.0
22	-	-	-	-	7.06	0.15	-	-	-	-	-	5.0
23	0.50	-	-	0.20	9.07	0.17	-	-	-	7.40	7.03	5.0
24	0.45	-	-	0.16	7.44	0.16	-	-	-	7.50	7.05	5.0
25	0.54	-	-	0.18	6.91	0.16	-	-	-	7.40	7.13	5.0
26	0.42	-	-	0.19	6.44	0.15	-	0.005	0.011	7.50	7.18	5.0
27	0.44	-	-	0.17	7.15	0.16	-	-	-	7.52	7.16	5.0
28	-	-	-	-	6.83	0.15	-	-	-	-	-	4.5
29	-	-	-	-	6.96	0.15	-	-	-	-	-	5.0
30	0.48	-	-	0.18	7.36	0.16	-	-	-	7.45	7.18	5.0
31	0.52	-	-	0.14	6.83	0.17	-	-	-	7.35	7.00	5.0

* Total Fe Res for month <0.15 mg/L. Avg per day <0.05 mg/L

TABLE 2.1: PARTICULATE REMOVAL PROFILE (APRIL/84)-BARE POINT

MOE WPOS PROTOCOL

DATE	TURBIDITY (NTU)				COAGULANT	COAG. AID	FILTER AID	METAL RES. (Al) (mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.	mg/L	mg/L	mg/L	RAW	TREATED	RAW	TREATED	(C)
1	-	-	-	-	7.55	0.18	-	-	-	-	-	5.0
2	0.37	-	-	0.14	6.72	0.19	-	-	-	7.76	7.20	5.0
3	0.40	-	-	0.16	6.14	0.18	-	-	-	7.84	7.24	5.0
4	0.39	-	-	0.19	6.14	0.18	-	-	-	7.86	7.28	5.0
5	0.47	-	-	0.13	6.19	0.18	-	-	-	7.85	7.27	5.0
6	0.32	-	-	0.12	6.10	0.17	-	0.003	0.008	7.88	7.26	5.0
7	-	-	-	-	6.33	0.17	-	-	-	-	-	5.0
8	-	-	-	-	6.43	0.17	-	-	-	-	-	5.0
9	-	-	-	-	7.43	0.18	-	-	-	7.81	7.23	5.0
10	-	-	-	-	6.98	0.18	-	-	-	7.85	7.28	5.0
11	-	-	-	-	6.41	0.17	-	-	-	7.84	7.26	5.0
12	0.33	-	-	0.08	6.85	0.18	-	-	-	7.90	7.31	5.0
13	0.37	-	-	0.08	7.20	0.18	-	0.005	0.011	7.85	7.32	5.0
14	0.34	-	-	0.09	7.87	0.17	-	-	-	-	-	5.0
15	0.41	-	-	0.09	7.80	0.19	-	-	-	-	-	5.0

DATE	TURBIDITY (NTU)				COAGULANT	COAG. AID	FILTER AID	METAL RES. (Al) (mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.	mg/L	mg/L	mg/L	RAW	TREATED	RAW	TREATED	(C)
16	0.46	-	-	0.10	7.76	0.18	-	-	-	7.81	7.24	5.0
17	0.43	-	-	0.07	8.43	0.16	-	-	-	7.78	7.20	5.0
18	0.38	-	-	0.09	7.68	0.17	-	-	-	7.80	7.27	5.0
19	0.38	-	-	0.08	6.56	0.17	-	0.005	0.011	7.85	7.30	5.0
20	0.40	-	-	0.08	5.78	0.17	-	-	-	-	-	6.0
21	0.39	-	-	0.08	6.08	0.17	-	-	-	-	-	6.0
22	0.40	-	-	0.10	8.37	0.18	-	-	-	-	-	6.0
23	0.45	-	-	0.10	7.73	0.18	-	-	-	7.80	7.20	6.0
24	0.40	-	-	0.10	8.39	0.18	-	-	-	7.82	7.27	6.5
25	0.43	-	-	0.09	6.19	0.17	-	-	-	7.77	7.18	7.0
26	0.45	-	-	0.13	7.33	0.18	-	0.005	0.008	7.83	7.24	7.0
27	0.50	-	-	0.11	8.31	0.17	-	-	-	-	-	6.0
28	0.67	-	-	0.10	8.38	0.18	-	-	-	-	-	6.0
29	0.85	-	-	0.10	10.17	0.19	-	-	-	-	-	7.0
30	0.68	-	-	0.10	8.12	0.20	-	0.005	0.008	7.77	7.11	6.5

* Total Fe Res for month <0.01 mg/L. Avg per day <0.05 mg/L

TABLE 2.1: PARTICULATE REMOVAL PROFILE (JULY/84)-BARE POINT
MOE WPOS PROTOCOL

DATE	TURBIDITY (NTU)				COAGULANT	COAG. AID	FILTER AID	METAL RES. (Al) (mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.	mg/L	mg/L	mg/L	RAW	TREATED	RAW	TREATED	(C)
1	0.61	-	-	0.03	9.86	0.20	-	-	-	7.40	7.15	10.5
2	0.65	-	-	0.03	10.50	0.22	-	-	-	7.40	7.20	10.5
3	0.68	-	-	0.03	11.05	0.21	-	-	-	7.50	7.10	11.5
4	0.72	-	-	0.03	9.21	0.21	-	-	-	7.50	7.15	10.5
5	0.84	-	-	0.03	12.21	0.20	-	-	-	7.50	7.10	11.0
6	0.75	-	-	0.03	10.73	0.18	-	-	-	7.50	7.15	12.0
7	0.63	-	-	0.03	11.03	0.22	-	-	-	7.50	7.10	12.5
8	0.68	-	-	0.03	11.83	0.22	-	-	-	-	-	11.5
9	0.67	-	-	0.04	11.05	0.18	-	-	-	-	-	11.5
10	0.71	-	-	0.04	11.15	0.21	-	-	-	-	-	10.0
11	0.72	-	-	0.04	11.84	0.19	-	-	-	-	-	11.0
12	0.74	-	-	0.05	9.18	0.13	-	-	-	-	-	10.5
13	0.83	-	-	0.03	10.59	0.18	-	-	-	-	-	11.5
14	0.80	-	-	0.03	11.43	0.13	-	-	-	-	-	14.0
15	0.65	-	-	0.03	10.18	0.13	-	-	-	-	-	12.5

DATE	TURBIDITY (NTU) RAW	SET.	FILTER	TREAT.	COAGULANT mg/L	COAG. AID mg/L	FILTER AID mg/L	METAL RES. (Al) (mg/L) RAW	TREATED	pH RAW	pH TREATED	TEMP (C)
16	0.68	-	-	0.06	11.00	0.14	-	-	-	-	-	9.0
17	0.70	-	-	0.06	8.79	0.14	-	-	-	-	-	9.0
18	0.73	-	-	0.03	11.68	0.16	-	-	-	-	-	12.5
19	0.72	-	-	0.04	11.57	0.16	-	-	-	-	-	11.3
20	0.81	-	-	0.03	10.82	0.18	-	-	-	-	-	12.5
21	0.77	-	-	0.03	10.93	0.16	-	-	-	-	-	13.0
22	0.78	-	-	0.04	11.43	0.10	-	-	-	-	-	14.5
23	0.76	-	-	0.04	10.21	0.06	-	-	-	-	-	11.5
24	0.66	-	-	0.06	11.22	0.07	-	-	-	7.60	7.01	10.0
25	0.58	-	-	0.07	11.00	0.10	-	-	-	7.76	7.05	12.0
26	0.52	-	-	0.06	11.14	0.08	-	-	-	7.73	7.02	11.0
27	0.51	-	-	0.06	10.93	0.08	-	0.005	-	7.88	7.03	15.0
28	0.47	-	-	0.06	9.36	0.08	-	-	-	-	-	12.0
29	0.54	-	-	0.07	9.22	0.08	-	-	-	-	-	10.0
30	0.60	-	-	0.08	10.12	0.07	-	-	-	-	-	15.0
31	0.51	-	-	0.06	9.39	0.09	-	-	-	8.00	7.02	15.0

* Fe Res - Avg per day 0.37 mg/L

TABLE 2.1: PARTICULATE REMOVAL PROFILE (OCT/84)-BARE POINT

MOE WPOS PROTOCOL

DATE	TURBIDITY (NTU) RAW	SET.	FILTER	TREAT.	COAGULANT mg/L	COAG. AID mg/L	FILTER AID mg/L	METAL RES. (Al) (mg/L) RAW	TREATED	pH RAW	TREATED	TEMP (C)
1	0.72	-	-	0.09	9.75	0.16	-	-	-	7.75	7.12	10.0
2	0.64	-	-	0.08	9.39	0.12	-	-	-	7.84	7.20	11.0
3	0.77	-	-	0.09	9.84	0.13	-	-	-	7.58	7.16	11.0
4	0.72	-	-	0.09	9.74	0.08	-	-	-	7.80	7.15	11.0
5	0.65	-	-	0.09	10.80	0.08	-	0.005	0.008	7.82	7.17	11.0
6	0.71	-	-	0.08	9.50	0.08	-	-	-	-	-	11.0
7	0.70	-	-	0.10	8.98	0.08	-	-	-	-	-	11.5
8	0.68	-	-	0.10	9.66	0.08	-	-	-	-	-	11.0
9	0.50	-	-	0.10	8.33	0.09	-	-	-	7.84	7.15	11.0
10	0.50	-	-	0.10	10.45	0.08	-	-	-	7.82	7.13	11.0
11	0.54	-	-	0.10	9.93	0.09	-	-	-	7.84	7.15	12.0
12	0.52	-	-	0.10	9.40	0.08	-	0.003	0.005	7.82	7.16	12.0
13	0.48	-	-	0.10	14.87	0.07	-	-	-	-	-	12.0
14	0.50	-	-	-	14.02	0.07	-	-	-	-	-	12.0
15	0.57	-	-	0.07	7.95	0.10	-	-	-	7.88	7.12	12.0

DATE	TURBIDITY (NTU) RAW	SET.	FILTER	TREAT.	COAGULANT mg/L	COAG. AID mg/L	FILTER AID mg/L	METAL RES. (Al) (mg/L) RAW	TREATED	pH RAW	TREATED	TEMP (C)
16	0.59	-	-	0.09	9.45	0.11	-	-	-	7.91	7.16	12.0
17	2.50	-	-	0.06	10.98	0.08	-	-	-	7.85	7.20	12.0
18	1.20	-	-	0.02	9.54	0.07	-	-	-	7.85	7.27	12.0
19	2.05	-	-	0.03	9.34	0.09	-	0.003	0.007	-	-	12.0
20	1.60	-	-	0.02	10.03	0.09	-	-	-	-	-	11.0
21	0.95	-	-	0.02	9.29	0.11	-	-	-	-	-	11.0
22	1.00	-	-	0.02	9.44	0.96	-	-	-	7.75	7.05	10.5
23	0.75	-	-	0.03	10.00	0.83	-	-	-	7.69	7.02	10.0
24	0.84	-	-	0.03	9.18	0.77	-	-	-	7.68	7.00	10.0
25	0.78	-	-	0.03	9.20	0.09	-	-	-	7.77	7.09	10.0
26	0.91	-	-	0.10	9.93	0.09	-	0.008	0.008	7.73	7.09	10.0
27	1.10	-	-	0.11	9.11	0.09	-	-	-	-	-	10.0
28	0.87	-	-	0.13	9.34	0.08	-	-	-	-	-	10.0
29	0.99	-	-	0.12	9.52	0.09	-	-	-	7.75	7.10	10.0
30	1.00	-	-	0.10	10.31	0.10	-	-	-	7.73	7.11	10.0
31	-	-	-	-	9.06	0.11	-	-	-	7.78	7.08	10.0

* Fe Res - Avg per day 0.05 mg/L

TABLE 2.1: PARTICULATE REMOVAL PROFILE (JAN/85)-BARE POINT

MOE WPOS PROTOCOL

DATE	TURBIDITY (NTU)				COAGULANT	COAG. AID	FILTER AID	METAL RES. (Al) (mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.	mg/L	mg/L	mg/L	RAW	TREATED	RAW	TREATED	(C)
1	0.69	-	-	0.11	8.90	0.16	-	-	-	-	-	4.5
2	0.66	-	-	0.10	9.43	0.18	-	-	-	7.82	7.15	4.5
3	0.70	-	-	0.11	8.73	0.19	-	-	-	7.60	7.12	5.0
4	0.60	-	-	0.11	8.88	0.18	-	0.005	0.008	7.67	7.17	4.5
5	0.67	-	-	0.11	8.80	0.19	-	-	-	-	-	4.5
6	0.67	-	-	0.11	11.86	0.19	-	-	-	-	-	4.5
7	0.73	-	-	0.13	9.63	0.18	-	-	-	7.62	7.13	4.5
8	1.08	-	-	0.18	11.10	0.18	-	-	-	7.66	7.07	4.5
9	0.67	-	-	0.12	10.17	0.15	-	-	-	-	-	4.5
10	0.58	-	-	0.15	10.01	0.17	-	-	-	7.60	7.11	4.5
11	0.53	-	-	0.10	10.14	0.16	-	0.030	0.080	7.69	7.10	4.5
12	0.55	-	-	0.14	9.44	0.17	-	-	-	-	-	4.5
13	0.70	-	-	0.14	7.25	0.19	-	-	-	-	-	4.5
14	0.78	-	-	0.22	8.11	0.20	-	-	-	7.68	7.08	4.5
15	0.67	-	-	0.16	7.93	0.18	-	-	-	7.69	7.10	4.5

TABLE 2.1 (cont'd)

DATE	TURBIDITY (NTU)				COAGULANT	COAG. AID	FILTER AID	METAL RES. (Al) (mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.	mg/L	mg/L	mg/L	RAW	TREATED	RAW	TREATED	(C)
16	0.72	-	-	0.14	8.74	0.21	-	-	-	7.66	7.18	4.0
17	0.69	-	-	0.14	8.58	0.17	-	-	-	7.63	7.15	4.5
18	0.72	-	-	0.14	8.76	0.20	-	0.050	0.008	7.59	7.20	4.5
19	0.58	-	-	0.11	8.40	0.20	-	-	-	-	-	4.5
20	0.56	-	-	0.10	9.15	0.20	-	-	-	-	-	4.5
21	0.60	-	-	0.12	8.35	0.18	-	-	-	7.72	7.15	4.5
22	0.61	-	-	0.09	9.17	0.21	-	-	-	7.62	7.13	4.5
23	0.61	-	-	0.10	9.45	0.22	-	-	-	7.57	7.10	4.5
24	0.60	-	-	0.10	9.94	0.28	-	-	-	7.60	7.12	4.5
25	0.58	-	-	0.07	8.12	0.34	-	0.050	0.080	7.51	7.05	4.5
26	0.52	-	-	0.06	8.52	0.34	-	-	-	-	-	5.0
27	0.52	-	-	0.06	8.69	0.34	-	-	-	-	-	5.0
28	0.52	-	-	0.07	9.94	0.22	-	-	-	7.77	7.17	5.0
29	0.53	-	-	0.08	8.22	0.19	-	-	-	7.73	7.10	5.0
30	0.52	-	-	0.07	10.12	0.21	-	-	-	7.72	7.18	5.0
31	0.53	-	-	0.08	8.38	0.21	-	0.030	0.008	7.71	7.10	5.0

* Total Fe Res for month <0.15 mg/L, Avg per day <0.05 mg/L

TABLE 2.1: PARTICULATE REMOVAL PROFILE (APRIL/85)-BARE POINT

MOE WPOS PROTOCOL

DATE	TURBIDITY (NTU)				COAGULANT	COAG. AID	FILTER AID	METAL RES. (Al) (mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.	mg/L	mg/L	mg/L	RAW	TREATED	RAW	TREATED	(C)
1	0.40	-	-	0.10	7.58	0.19	-	-	-	7.70	-	5.0
2	0.37	-	-	0.14	8.47	0.18	-	-	-	7.73	7.10	5.0
3	0.35	-	-	0.08	6.58	0.18	-	-	-	7.69	7.15	5.0
4	0.27	-	-	0.07	6.76	0.17	-	0.003	0.008	7.66	7.12	5.0
5	0.25	-	-	0.11	6.82	0.18	-	-	-	-	7.20	5.0
6	0.28	-	-	0.10	6.70	0.17	-	-	-	-	-	5.0
7	0.25	-	-	0.10	6.82	0.16	-	-	-	-	-	5.0
8	0.26	-	-	0.07	6.67	0.17	-	-	-	-	-	5.0
9	0.28	-	-	0.08	7.18	0.15	-	-	-	7.60	7.11	5.0
10	0.28	-	-	0.08	6.62	0.18	-	-	-	7.79	7.28	5.0
11	0.28	-	-	0.07	7.41	0.18	-	-	-	7.62	7.15	5.0
12	0.28	-	-	0.08	7.43	0.19	-	0.003	0.008	7.64	7.16	5.0
13	0.27	-	-	0.08	6.51	0.18	-	-	-	-	-	5.0
14	0.26	-	-	0.08	6.80	0.18	-	-	-	-	-	5.0
15	0.30	-	-	0.07	7.32	0.18	-	-	-	7.70	7.15	5.0

TABLE 2.1 (cont'd)

DATE	TURBIDITY (NTU)				COAGULANT	COAG. AID	FILTER AID	METAL RES. (Al) (mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.	mg/L	mg/L	mg/L	RAW	TREATED	RAW	TREATED	(C)
16	0.31	-	-	0.08	6.45	0.18	-	-	-	7.76	7.20	5.5
17	0.55	-	-	0.10	7.50	0.18	-	-	-	7.62	7.20	5.0
18	0.76	-	-	0.08	7.48	0.17	-	-	-	7.60	7.13	5.0
19	0.33	-	-	0.10	7.25	0.19	-	0.003	0.011	7.68	7.08	5.0
20	0.33	-	-	0.08	6.83	0.18	-	-	-	-	-	5.0
21	0.33	-	-	0.09	8.60	0.17	-	-	-	-	-	5.0
22	0.38	-	-	0.08	6.19	0.18	-	-	-	7.61	7.08	5.5
23	0.35	-	-	0.09	7.05	0.18	-	-	-	7.63	7.10	6.0
24	0.39	-	-	0.07	7.36	0.18	-	-	-	7.64	7.11	6.0
25	0.38	-	-	0.08	6.89	0.18	-	-	-	7.60	7.06	6.0
26	0.37	-	-	0.08	7.52	0.22	-	0.003	0.008	7.58	7.06	6.0
27	0.42	-	-	0.10	7.28	0.17	-	-	-	-	-	6.0
28	0.45	-	-	0.08	9.09	0.18	-	-	-	-	-	6.0
29	0.49	-	-	0.11	7.27	0.17	-	-	-	7.56	7.15	6.0
30	0.40	-	-	0.09	7.46	0.17	-	-	-	7.65	7.10	6.0
31	-	-	-	-	-	-	-	-	-	-	-	-

* Total Fe Res for month <0.15 mg/L. Avg per day <0.05 mg/L

TABLE 2.1: PARTICULATE REMOVAL PROFILE (JULY/85)-BARE POINT

MOE WPOS PROTOCOL

DATE	TURBIDITY (NTU)				COAGULANT	COAG. AID	FILTER AID	METAL RES. (Al) (mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.	mg/L	mg/L	mg/L	RAW	TREATED	RAW	TREATED	(C)
1	0.57	-	-	0.09	9.22	0.15	-	-	-	-	-	11.0
2	0.43	-	-	0.09	8.94	0.17	-	-	-	7.80	7.20	10.5
3	0.42	-	-	0.09	6.87	0.17	-	-	-	7.80	7.18	10.0
4	0.44	-	-	0.13	7.60	0.18	-	-	-	7.73	7.20	10.0
5	0.43	-	-	0.14	4.39	0.19	-	0.003	0.008	7.75	7.14	12.0
6	0.44	-	-	0.10	7.39	0.18	-	-	-	-	-	14.0
7	0.56	-	-	0.10	8.48	0.21	-	-	-	-	-	13.0
8	0.77	-	-	0.05	7.79	0.20	-	-	-	-	-	12.0
9	0.87	-	-	0.11	6.60	0.18	-	-	-	-	-	11.0
10	0.55	-	-	0.10	7.19	0.19	-	-	-	7.90	7.17	9.5
11	0.61	-	-	0.11	7.27	0.18	-	-	-	7.74	7.08	10.0
12	0.61	-	-	0.11	7.88	0.20	-	0.003	0.011	7.70	7.03	10.0
13	0.65	-	-	0.11	7.91	0.20	-	-	-	-	-	12.0
14	0.56	-	-	0.11	7.85	0.17	-	-	-	-	-	14.0
15	0.48	-	-	0.10	8.06	0.17	-	-	-	7.49	7.12	11.0

TABLE 2.1 (cont'd)

DATE	TURBIDITY (NTU)				COAGULANT	COAG. AID	FILTER AID	METAL RES. (Al) (mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.	mg/L	mg/L	mg/L	RAW	TREATED	RAW	TREATED	(C)
16	0.50	-	-	0.10	9.20	0.16	-	-	-	7.75	7.07	13.0
17	0.57	-	-	0.11	9.88	0.20	-	-	-	7.67	7.08	14.0
18	0.69	-	-	0.14	8.54	**	-	-	-	-	7.00	14.0
19	0.75	-	-	0.16	7.08	0.23	-	0.003	0.008	7.60	7.03	11.0
20	0.64	-	-	0.13	5.97	0.28	-	-	-	-	-	10.0
21	0.56	-	-	0.09	3.61	0.25	-	-	-	-	-	9.0
22	0.56	-	-	0.08	2.78	0.25	-	-	-	7.59	7.15	9.0
23	0.59	-	-	0.11	1.35	0.24	-	-	-	7.67	7.20	10.0
24	0.48	-	-	0.09	3.86	0.18	-	-	-	7.67	7.20	11.0
25	0.54	-	-	0.09	2.75	0.25	-	-	-	7.82	7.22	14.0
26	0.46	-	-	0.09	2.60	0.26	-	0.003	0.011	7.82	7.34	13.0
27	0.51	-	-	0.11	3.77	0.22	-	-	-	-	-	12.0
28	0.54	-	-	0.13	3.42	0.27	-	-	-	-	-	10.0
29	0.46	-	-	0.11	4.27	0.27	-	-	-	7.75	7.27	10.5
30	0.63	-	-	0.12	3.70	0.27	-	-	-	7.78	7.28	11.0
31	0.39	-	-	0.12	4.32	0.26	-	-	-	7.80	7.25	12.0

* Total Fe Res for month <0.15 mg/L. Avg per day <0.05 mg/L

** LT35 used instead of 8171, from the 19th to the 31st of July 85.

TABLE 2.1: PARTICULATE REMOVAL PROFILE (OCT/85)-BARE POINT
MOE WPOS PROTOCOL

DATE	TURBIDITY (NTU) RAW	SET.	FILTER	TREAT.	COAGULANT mg/L	COAG. AID mg/L	FILTER AID mg/L	METAL RES. (Al) (mg/L) RAW	TREATED	pH RAW	TREATED	TEMP (C)
1	0.88	-	-	0.13	6.19	0.29	-	-	-	7.74	7.28	12.0
2	0.76	-	-	0.11	5.70	0.29	-	-	-	7.80	7.25	12.0
3	0.90	-	-	0.12	6.51	0.29	-	-	-	7.77	7.30	12.0
4	1.08	-	-	0.16	6.50	0.28	-	0.003	0.008	7.74	7.20	12.0
5	0.80	-	-	0.13	7.21	0.20	-	-	-	-	-	11.5
6	0.77	-	-	0.12	6.04	0.25	-	-	-	-	-	11.0
7	0.78	-	-	0.12	6.34	0.32	-	-	-	7.66	7.30	10.5
8	1.27	-	-	0.12	6.73	0.28	-	-	-	7.78	7.23	11.0
9	0.74	-	-	0.10	5.29	0.29	-	-	-	7.79	7.32	11.0
10	0.68	-	-	0.10	4.35	0.27	-	-	-	7.70	7.26	10.5
11	0.89	-	-	0.16	5.31	0.26	-	0.003	0.006	7.65	7.27	10.0
12	1.43	-	-	0.53	7.10	0.27	-	-	-	-	-	10.0
13	0.73	-	-	0.12	7.08	0.23	-	-	-	-	-	10.0
14	0.86	-	-	0.10	6.60	0.27	-	-	-	-	-	10.0
15	1.08	-	-	0.16	7.70	0.27	-	-	-	7.69	7.10	10.0

TABLE 2.1 (cont'd)

DATE	TURBIDITY (NTU) RAW	SET.	FILTER	TREAT.	COAGULANT mg/L	COAG. AID mg/L	FILTER AID mg/L	METAL RES. (Al) (mg/L) RAW	TREATED	pH RAW	TREATED	TEMP (C)
16	0.90	-	-	0.16	7.44	0.28	-	-	-	7.64	7.08	10.0
17	1.10	-	-	0.14	8.66	0.28	-	-	-	7.65	7.15	10.0
18	0.72	-	-	0.11	5.66	0.29	-	0.003	0.008	7.59	7.00	10.0
19	0.82	-	-	0.13	5.73	0.28	-	-	-	-	-	10.0
20	0.91	-	-	0.14	10.10	0.29	-	-	-	-	-	10.0
21	1.50	-	-	0.45	7.44	0.29	-	-	-	7.67	7.05	10.0
22	1.00	-	-	0.25	7.49	0.28	-	-	-	7.67	7.10	10.0
23	0.66	-	-	0.11	5.79	0.27	-	-	-	7.69	7.23	10.0
24	1.10	-	-	0.18	5.81	0.27	-	-	-	7.64	7.21	10.0
25	0.76	-	-	0.11	8.01	0.29	-	0.003	0.008	7.66	7.20	10.0
26	0.71	-	-	0.11	6.56	0.30	-	-	-	-	-	10.0
27	0.66	-	-	0.10	6.51	0.30	-	-	-	-	-	10.0
28	0.67	-	-	0.09	5.33	0.29	-	-	-	7.70	7.25	10.0
29	0.85	-	-	0.10	6.68	0.29	-	-	-	7.70	7.15	10.0
30	0.82	-	-	0.11	6.30	0.26	-	-	-	7.71	7.25	10.0
31	1.09	-	-	0.46	5.70	0.27	-	-	-	7.54	7.15	10.0

* Total Fe Res for month <0.15 mg/L. Avg per day <0.05 mg/L

TABLE 2.1: PARTICULATE REMOVAL PROFILE (JAN/86)-BARE POINT

MOE WPOS PROTOCOL

DATE	TURBIDITY (NTU)				COAGULANT	COAG. AID	FILTER AID	METAL RES.(Al)(mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.	mg/L	mg/L	mg/L	RAW	TREATED	RAW	TREATED	(C)
1	0.58	-	-	0.09	4.02	0.22	-	-	-	-	-	5.0
2	0.58	-	-	0.10	4.63	0.27	-	-	-	7.68	7.13	5.0
3	0.55	-	-	0.10	4.98	0.27	-	0.000	0.000	7.64	7.14	5.0
4	0.52	-	-	0.10	4.63	0.26	-	-	-	-	-	5.0
5	0.54	-	-	0.09	8.01	0.25	-	-	-	-	-	5.0
6	0.61	-	-	0.12	4.55	0.28	-	-	-	7.64	7.30	5.0
7	0.55	-	-	0.09	3.20	0.26	-	-	-	7.71	7.20	5.0
8	0.54	-	-	0.09	3.69	0.27	-	-	-	7.66	7.16	5.0
9	0.55	-	-	0.09	3.76	0.26	-	-	-	7.65	7.16	5.0
10	0.50	-	-	0.09	4.26	0.27	-	0.003	0.008	7.71	7.16	5.0
11	0.47	-	-	0.10	3.99	0.25	-	-	-	-	-	5.0
12	0.56	-	-	0.11	3.39	0.26	-	-	-	-	-	5.0
13	0.57	-	-	0.11	2.82	0.25	-	-	-	7.49	7.18	5.0
14	0.55	-	-	0.14	3.66	0.26	-	-	-	-	-	4.5
15	0.54	-	-	0.12	3.92	0.24	-	-	-	7.67	7.30	5.0

DATE	TURBIDITY (NTU)				COAGULANT	COAG. AID	FILTER AID	METAL RES.(Al)(mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.	mg/L	mg/L	mg/L	RAW	TREATED	RAW	TREATED	(C)
16	0.50	-	-	0.10	4.72	0.27	-	-	-	7.57	7.10	5.0
17	0.44	-	-	0.09	3.83	0.25	-	0.003	0.008	7.58	7.08	4.5
18	0.64	-	-	0.19	5.04	0.26	-	-	-	-	-	4.5
19	0.60	-	-	0.11	3.91	0.26	-	-	-	-	-	5.0
20	0.56	-	-	0.11	4.20	0.25	-	-	-	7.62	7.02	5.0
21	0.50	-	-	0.09	3.37	0.26	-	-	-	7.61	7.10	4.5
22	0.50	-	-	0.09	3.39	0.26	-	-	-	7.62	7.21	4.5
23	0.55	-	-	0.09	2.89	0.25	-	-	-	7.64	7.20	5.0
24	0.70	-	-	0.12	3.36	0.25	-	0.003	0.011	7.61	7.19	4.5
25	0.52	-	-	0.12	3.74	0.25	-	-	-	-	-	4.5
26	0.53	-	-	0.09	4.00	0.24	-	-	-	-	-	5.0
27	0.55	-	-	0.11	3.72	0.12	-	-	-	7.57	7.10	5.0
28	0.51	-	-	0.10	2.86	0.12	-	-	-	7.55	7.11	5.0
29	0.50	-	-	0.11	3.76	0.12	-	-	-	7.57	7.13	5.0
30	0.48	-	-	0.10	3.84	0.12	-	-	-	7.55	7.09	5.0
31	0.47	-	-	0.12	3.66	0.13	-	0.003	0.008	7.64	7.13	5.0

* Total Fe Res. for month <0.15 mg/L, Avg per day <0.05 mg/L

NOTE: POLYMER DOSAGE HALFED AS OF MONDAY JAN. 27/86

TABLE 2.1: PARTICULATE REMOVAL PROFILE (APRIL/86)-BARE POINT

MOE WPOS PROTOCOL

DATE	TURBIDITY (NTU)				COAGULANT	COAG. AID	FILTER AID	METAL RES.(Al)(mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.	mg/L	mg/L	mg/L	RAW	TREATED	RAW	TREATED	(C)
1	0.32	-	-	0.10	3.68	0.26	-	-	-	7.67	7.25	5.0
2	0.33	-	-	0.09	3.54	0.25	-	-	-	7.68	7.20	5.0
3	0.33	-	-	0.09	3.18	0.26	-	-	-	7.67	7.14	5.0
4	0.29	-	-	0.09	2.75	0.26	-	0.003	0.008	7.66	7.18	5.0
5	0.39	-	-	0.10	3.02	0.24	-	-	-	-	-	5.0
6	0.33	-	-	0.10	2.75	0.26	-	-	-	-	-	5.0
7	0.37	-	-	0.11	2.28	0.23	-	-	-	7.61	7.18	5.0
8	0.35	-	-	0.09	2.34	0.26	-	-	-	7.58	7.09	5.0
9	0.33	-	-	0.09	2.79	0.26	-	-	-	7.56	7.12	5.0
10	0.33	-	-	0.09	2.78	0.25	-	-	-	7.46	7.05	5.0
11	0.33	-	-	0.08	2.71	0.25	-	0.003	0.008	7.65	7.18	5.0
12	0.35	-	-	0.09	4.70	0.26	-	-	-	-	-	5.0
13	0.39	-	-	0.10	2.81	0.24	-	-	-	-	-	5.0
14	0.37	-	-	0.11	3.69	0.25	-	-	-	7.56	7.10	5.0
15	0.34	-	-	0.09	4.24	0.25	-	-	-	7.48	6.98	5.5

DATE	TURBIDITY (NTU)				COAGULANT	COAG. AID	FILTER AID	METAL RES.(Al)(mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.	mg/L	mg/L	mg/L	RAW	TREATED	RAW	TREATED	(C)
16	0.36	-	-	0.09	3.16	0.24	-	-	-	7.47	7.05	5.0
17	0.37	-	-	0.10	3.17	0.25	-	-	-	7.52	6.98	5.5
18	0.35	-	-	0.10	3.01	0.25	-	0.003	0.008	7.52	7.03	6.0
19	0.35	-	-	0.10	3.73	0.25	-	-	-	-	-	6.0
20	0.35	-	-	0.09	2.85	0.26	-	-	-	-	-	5.0
21	0.40	-	-	0.09	2.74	0.25	-	-	-	7.48	7.02	5.0
22	0.40	-	-	0.12	3.68	0.25	-	-	-	7.55	7.00	6.0
23	0.70	-	-	0.15	4.69	0.25	-	-	-	7.52	7.00	6.0
24	0.95	-	-	0.17	6.60	0.24	-	-	-	7.53	6.99	6.0
25	0.69	-	-	0.12	4.96	0.26	-	0.003	0.011	7.52	6.96	6.0
26	0.52	-	-	0.11	4.44	0.24	-	-	-	-	-	6.0
27	0.60	-	-	0.08	3.90	0.25	-	-	-	-	-	6.0
28	0.62	-	-	0.10	4.13	0.25	-	-	-	7.40	6.82	6.0
29	0.43	-	-	0.10	4.17	0.25	-	-	-	7.35	6.80	6.0
30	0.48	-	-	0.09	3.63	0.25	-	-	-	7.27	6.72	6.0

Total Fe Res for month <0.10 mg/L, Avg per day <0.05 mg/L

TABLE 2.1: PARTICULATE REMOVAL PROFILE (JULY/86)-BARE POINT
MOE WPOS PROTOCOL

DATE	TURBIDITY (NTU)				COAGULANT	COAG. AID	FILTER AID	METAL RES.(Al)(mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.	mg/L	mg/L	mg/L	RAW	TREATED	RAW	TREATED	(C)
1	0.52	-	-	0.10	5.99	0.26	-	-	-	-	-	11.0
2	0.49	-	-	0.11	4.32	0.29	-	-	-	7.75	7.27	12.0
3	0.50	-	-	0.11	2.65	0.27	-	-	-	7.80	7.30	12.0
4	0.60	-	-	0.12	4.11	0.29	-	0.003	0.008	7.84	7.31	12.0
5	0.54	-	-	0.15	5.46	0.28	-	-	-	-	-	13.0
6	0.50	-	-	0.10	6.07	0.28	-	-	-	-	-	13.0
7	0.53	-	-	0.10	5.29	0.30	-	-	-	7.70	7.30	10.0
8	0.48	-	-	0.11	5.95	0.28	-	-	-	7.61	7.16	10.0
9	0.48	-	-	0.09	6.30	0.28	-	-	-	7.83	7.21	13.5
10	0.45	-	-	0.10	5.42	0.30	-	-	-	7.86	7.29	15.0
11	0.46	-	-	0.09	5.16	0.28	-	0.003	0.011	7.50	7.29	15.0
12	0.46	-	-	0.08	5.87	0.22	-	-	-	-	-	15.0
13	0.56	-	-	0.10	5.77	0.28	-	-	-	-	-	15.0
14	0.53	-	-	0.10	8.40	0.18	-	-	-	7.83	7.25	14.0
15	0.52	-	-	0.11	7.18	0.27	-	-	-	7.83	7.30	12.0

DATE	TURBIDITY (NTU)				COAGULANT	COAG. AID	FILTER AID	METAL RES.(Al)(mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.	mg/L	mg/L	mg/L	RAW	TREATED	RAW	TREATED	(C)
16	0.55	-	-	0.09	5.96	0.26	-	-	-	7.81	7.26	10.0
17	0.59	-	-	0.11	4.86	0.28	-	-	-	7.71	7.26	12.0
18	0.55	-	-	0.10	5.63	0.27	-	0.003	0.008	7.79	7.27	12.0
19	0.58	-	-	0.09	6.69	0.27	-	-	-	-	-	11.0
20	0.54	-	-	0.09	6.39	0.27	-	-	-	-	-	12.0
21	0.54	-	-	0.09	4.87	0.27	-	-	-	7.70	7.21	12.0
22	0.51	-	-	0.09	6.39	0.26	-	-	-	7.70	7.35	12.0
23	0.52	-	-	0.11	6.48	0.27	-	-	-	7.85	7.27	16.0
24	0.59	-	-	0.13	4.83	0.27	-	-	-	7.87	7.22	13.0
25	0.66	-	-	0.11	4.00	0.27	-	0.003	0.008	7.78	7.23	13.0
26	0.66	-	-	0.10	7.85	0.27	-	-	-	-	-	16.0
27	0.64	-	-	0.08	4.75	0.27	-	-	-	-	-	12.0
28	0.71	-	-	0.10	5.43	0.23	-	-	-	7.92	7.23	16.0
29	0.64	-	-	0.09	4.92	0.26	-	-	-	7.70	7.11	11.0
30	0.65	-	-	0.12	5.96	0.27	-	-	-	7.68	7.15	12.0
31	0.58	-	-	0.13	4.96	0.26	-	-	-	7.78	7.22	14.0

Total Fe Res for month <0.10 mg/L, Avg per day <0.05 mg/L

TABLE 2.1: PARTICULATE REMOVAL PROFILE (OCT/86)-BARE POINT
MOE WPOS PROTOCOL

DATE	TURBIDITY (NTU)				COAGULANT	COAG. AID	FILTER AID	METAL RES.(Al)(mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.	mg/L	mg/L	mg/L	RAW	TREATED	RAW	TREATED	(C)
1	0.70	-	-	0.09	3.65	0.24	-	-	-	7.80	7.39	10.0
2	0.67	-	-	0.10	3.03	0.24	-	-	-	7.60	7.43	10.5
3	0.56	-	-	0.12	3.14	0.26	-	0.005	0.008	7.77	7.35	12.0
4	0.59	-	-	0.10	2.61	0.25	-	-	-	-	-	12.0
5	0.52	-	-	0.10	2.73	0.26	-	-	-	-	-	11.0
6	0.64	-	-	0.11	2.57	0.25	-	-	-	7.70	7.28	11.0
7	1.00	-	-	0.20	3.79	0.22	-	-	-	7.57	7.23	10.0
8	0.70	-	-	0.11	4.57	0.25	-	-	-	7.45	7.09	10.0
9	0.62	-	-	0.11	4.43	0.26	-	-	-	7.55	7.06	10.0
10	0.66	-	-	0.10	3.52	0.27	-	0.003	0.010	7.58	7.10	10.5
11	0.66	-	-	0.09	5.39	0.24	-	-	-	-	-	10.5
12	0.70	-	-	0.12	3.33	0.23	-	-	-	-	-	10.0
13	0.67	-	-	0.10	4.36	0.23	-	-	-	-	-	10.0
14	0.72	-	-	0.11	3.20	0.24	-	-	-	7.60	7.36	10.0
15	0.72	-	-	0.13	4.63	0.23	-	0.010	0.020	7.80	7.32	10.0

DATE	TURBIDITY (NTU) RAW	SET.	FILTER	TREAT.	COAGULANT mg/L	COAG. AID mg/L	FILTER AID mg/L	METAL RES.(Al)(mg/L) RAW	TREATED	pH RAW	TREATED	TEMP (C)
16	0.69	-	-	0.11	3.73	0.24	-	-	-	7.70	7.31	10.0
17	0.63	-	-	0.11	4.59	0.25	-	-	-	7.77	7.35	10.0
18	0.77	-	-	0.14	5.27	0.25	-	-	-	-	-	10.0
19	0.91	-	-	0.19	3.70	0.26	-	-	-	-	-	10.0
20	1.12	-	-	0.45	5.79	0.23	-	-	-	7.60	7.40	10.0
21	0.97	-	-	0.36	6.27	0.25	-	-	-	7.73	7.24	10.0
22	0.99	-	-	0.34	7.27	0.25	-	-	-	7.68	7.26	10.0
23	0.73	-	-	0.25	5.88	0.29	-	-	-	7.65	7.20	10.0
24	0.73	-	-	0.14	5.31	0.31	-	0.008	0.015	7.60	7.16	10.0
25	0.73	-	-	0.14	6.46	0.34	-	-	-	-	-	10.0
26	0.82	-	-	0.32	4.60	0.29	-	-	-	-	-	10.0
27	0.84	-	-	0.12	6.42	0.28	-	-	-	7.60	7.13	10.0
28	0.67	-	-	0.11	6.30	0.24	-	-	-	7.63	7.10	10.0
29	0.75	-	-	0.24	7.51	0.25	-	-	-	7.60	7.19	10.0
30	0.62	-	-	0.14	6.16	0.23	-	-	-	7.64	7.11	7.0
31	1.66	-	-	0.23	7.29	0.25	-	0.010	0.015	7.60	7.06	7.0

Total Fe Res for month <0.50 mg/L, Avg per day <0.16 mg/L

TABLE 3

WATER PLANT OPTIMIZATION STUDY
"DISINFECTION SUMMARY"

TABLE 3.0: DISINFECTION SUMMARY -BARE POINT

MOE WPOS PROTOCOL

Month	Parameter	1986						1985						1984					
		PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION		
		MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG
JAN	Cl2 Demand																		
	Cl2 Dosage				1.96	1.06	1.52				1.94	1.62	1.75				1.73	1.41	1.58
	Ammonia																		
	SO2																		
	Residual Cl2 Free				1.42	1.19	1.29				1.5	1.23	1.32				1.42	1.24	1.33
	Residual Cl2 Combined																		
	Residual Cl2 Total																		
FEB	Cl2 Demand																		
	Cl2 Dosage				1.92	1.35	1.55				1.75	1.44	1.60				1.69	1.45	1.57
	Ammonia																		
	SO2																		
	Residual Cl2 Free				1.33	1.21	1.29				1.36	1.19	1.33				1.48	1.22	1.34
	Residual Cl2 Combined																		
	Residual Cl2 Total																		
MAR	Cl2 Demand																		
	Cl2 Dosage				1.55	1.36	1.47				1.82	1.27	1.55				1.66	1.34	1.49
	Ammonia																		
	SO2																		
	Residual Cl2 Free				1.32	1.21	1.28				1.40	1.03	1.26				1.45	1.18	1.33
	Residual Cl2 Combined																		
	Residual Cl2 Total																		
APR	Cl2 Demand																		
	Cl2 Dosage				1.75	1.39	1.56				1.61	1.30	1.47				1.70	1.38	1.55
	Ammonia																		
	SO2																		
	Residual Cl2 Free				1.37	1.22	1.29				1.45	1.11	1.28				1.40	1.14	1.29
	Residual Cl2 Combined																		
	Residual Cl2 Total																		

* Automatically maintained between 1.3 - 1.4 mg/L

** Constitutes total chlorine dosage applied for pre and post-chlorination

TABLE 3.0: DISINFECTION SUMMARY -BARE POINT

MOE WPOS PROTOCOL

		1986						1985						1984					
		PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION		
		MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG
MAY	Cl2 Demand																		
	Cl2 Dosage				1.84	1.43	1.58				1.88	1.57	1.71				1.97	1.56	1.71
	Ammonia																		
	SO2																		
	Residual Cl2 Free				1.42	1.22	1.30				1.40	1.17	1.30				1.45	1.14	1.30
	Residual Cl2 Combined																		
	Residual Cl2 Total																		
JUN	Cl2 Demand																		
	Cl2 Dosage				1.89	1.45	1.74				2.00	1.59	1.77				3.16	1.71	2.06
	Ammonia																		
	SO2																		
	Residual Cl2 Free				1.39	1.19	1.30				1.39	1.17	1.30				1.72	1.10	1.37
	Residual Cl2 Combined																		
	Residual Cl2 Total																		
JUL	Cl2 Demand																		
	Cl2 Dosage				2.06	1.23	1.73				2.31	1.51	1.83				2.02	1.60	1.76
	Ammonia																		
	SO2																		
	Residual Cl2 Free				1.46	1.12	1.28				1.43	1.16	1.29				1.55	1.16	1.32
	Residual Cl2 Combined																		
	Residual Cl2 Total																		
AUG	Cl2 Demand																		
	Cl2 Dosage				2.12	N/A	1.74				1.96	1.50	1.76				2.21	1.59	1.88
	Ammonia																		
	SO2																		
	Residual Cl2 Free				1.52	N/A	1.31				1.40	1.16	1.30				1.52	1.08	1.35
	Residual Cl2 Combined																		
	Residual Cl2 Total																		

* Automatically maintained between 1.3 - 1.4 mg/L

** Constitutes total chlorine dosage applied for pre and post-chlorination

TABLE 3.0: DISINFECTION SUMMARY -BARE POINT

MOE WPOS PROTOCOL

		1986						1985						1984					
		PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION		
		MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG
SEP	Cl2 Demand																		
	Cl2 Dosage				1.88	1.44	1.65				1.99	1.50	1.81				1.95	1.40	1.80
	Ammonia																		
	SO2																		
	Residual Cl2 Free				1.35	1.17	1.28				1.40	1.14	1.30				1.48	1.21	1.32
	Residual Cl2 Combined																		
	Residual Cl2 Total																		
OCT	Cl2 Demand																		
	Cl2 Dosage				2.06	1.48	1.76				2.15	1.63	1.79				1.93	1.52	1.74
	Ammonia																		
	SO2																		
	Residual Cl2 Free				1.46	1.10	1.30				1.50	1.18	1.27				1.49	1.11	1.31
	Residual Cl2 Combined																		
	Residual Cl2 Total																		
NOV	Cl2 Demand																		
	Cl2 Dosage				1.79	1.46	1.61				1.93	1.46	1.63				1.88	1.43	1.65
	Ammonia																		
	SO2																		
	Residual Cl2 Free				1.37	1.26	1.32				1.39	1.20	1.31				1.49	1.19	1.33
	Residual Cl2 Combined																		
	Residual Cl2 Total																		
DEC	Cl2 Demand																		
	Cl2 Dosage				1.99	1.40	1.63				1.95	1.37	1.58				1.98	1.60	1.73
	Ammonia																		
	SO2																		
	Residual Cl2 Free				1.37	1.19	1.30				1.38	1.15	1.28				1.42	1.21	1.33
	Residual Cl2 Combined																		
	Residual Cl2 Total																		

* Automatically maintained between 1.3 - 1.4 mg/L

** Constitutes total chlorine dosage applied for pre and post-chlorination

TABLE 3.2: DISINFECTION PROFILE (JAN/1984)-BARE POINT

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION Cl_2 Dem.	PRE-CHLORINATION Cl_2 Dos	PRE-CHLORINATION NH_3	PRE-CHLORINATION SO_2	PRE-CHLORINATION RESIDUAL Cl_2 Free	PRE-CHLORINATION RESIDUAL Cl_2 Comb	PRE-CHLORINATION RESIDUAL Cl_2 Total	POST-CHLORINATION Cl_2 Dem.	POST-CHLORINATION Cl_2 Dos.**	POST-CHLORINATION NH_3	POST-CHLORINATION SO_2	POST-CHLORINATION RESIDUAL Cl_2 Free	POST-CHLORINATION RESIDUAL Cl_2 Comb	POST-CHLORINATION RESIDUAL Cl_2 Total
1					*				1.51			1.38		
2					*				1.60			1.31		
3					*				1.56			1.29		
4					*				1.57			1.30		
5					*				1.47			1.31		
6					*				1.51			1.29		
7					*				1.60			1.24		
8					*				1.56			1.33		
9					*				1.63			1.28		
10					*				1.72			1.28		
11					*				1.71			1.27		
12					*				1.67			1.32		
13					*				1.70			1.33		
14					*				1.69			1.37		
15					*				1.73			1.38		

* Automatically maintained between 1.3 - 1.4 mg/L

** Constitutes total chlorine dosage applied for pre and post-chlorination

TABLE 3.2 (cont'd)

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION Cl2 Dem.	Dos.	NH3	SO2	RESIDUAL Cl2 Free	Comb	Total	POST-CHLORINATION Cl2 Dem.	Dos.**	NH3	SO2	RESIDUAL Cl2 Free	Comb	Total
16					*				1.69			1.42		
17					*				1.59			1.38		
18					*				1.53			1.35		
19					*				1.60			1.35		
20					*				1.42			1.34		
21					*				1.53			1.29		
22					*				1.63			1.38		
23					*				1.46			1.36		
24					*				1.52			1.34		
25					*				1.57			1.30		
26					*				1.41			1.32		
27					*				1.53			1.33		
28					*				1.48			1.32		
29					*				1.55			1.29		
30					*				1.58			1.33		
31					*				1.60			1.33		

TABLE 3.2: DISINFECTION PROFILE (APRIL/1984)-BARE POINT

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION Cl2 Dem.	Cl2 Dos.	NH3	SO2	RESIDUAL Cl2 Free	RESIDUAL Cl2 Comb	RESIDUAL Cl2 Total	POST-CHLORINATION Cl2 Dem.	Cl2 Dos.**	NH3	SO2	RESIDUAL Cl2 Free	RESIDUAL Cl2 Comb	RESIDUAL Cl2 Total
1					*				1.65			1.25		
2					*				1.65			1.29		
3					*				1.53			1.34		
4					*				1.46			1.25		
5					*				1.52			1.28		
6					*				1.64			1.36		
7					*				1.58			1.33		
8					*				1.43			1.34		
9					*				1.57			1.36		
10					*				1.56			1.33		
11					*				1.48			1.34		
12					*				1.43			1.39		
13					*				1.45			1.28		
14					*				1.41			1.28		
15					*				1.54			1.40		

* Automatically maintained between 1.3 - 1.4 mg/L

** Constitutes total chlorine dosage applied for pre and post-chlorination

TABLE 3.2 (cont'd)

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION							POST-CHLORINATION						
	Cl2		NH3	SO2	RESIDUAL Cl2			Cl2		NH3	SO2	RESIDUAL Cl2		
	Dem.	Dos.			Free	Comb	Total	Dem.	Dos.**			Free	Comb	Total
16					*				1.58			1.38		
17					*				1.56			1.40		
18					*				1.57			1.33		
19					*				1.54			1.30		
20					*				1.38			1.22		
21					*				1.44			1.17		
22					*				1.41			1.30		
23					*				1.59			1.31		
24					*				1.48			1.32		
25					*				1.50			1.23		
26					*				1.57			1.14		
27					*				1.57			1.33		
28					*				1.62			1.31		
29					*				1.62			1.26		
30					*				1.70			1.27		

TABLE 3.2: DISINFECTION PROFILE (JULY/1984)-BARE POINT

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION Cl2 Dem.	PRE-CHLORINATION Cl2 Dos.	PRE-CHLORINATION NH3	PRE-CHLORINATION SO2	PRE-CHLORINATION RESIDUAL Cl2 Free	PRE-CHLORINATION RESIDUAL Cl2 Comb	PRE-CHLORINATION RESIDUAL Cl2 Total	POST-CHLORINATION Cl2 Dem.	POST-CHLORINATION Cl2 Dos.**	POST-CHLORINATION NH3	POST-CHLORINATION SO2	POST-CHLORINATION RESIDUAL Cl2 Free	POST-CHLORINATION RESIDUAL Cl2 Comb	POST-CHLORINATION RESIDUAL Cl2 Total
1					*				2.02			1.35		
2					*				1.79			1.33		
3					*				1.85			1.38		
4					*				1.77			1.39		
5					*				1.81			1.31		
6					*				1.62			1.35		
7					*				1.80			1.20		
8					*				1.71			1.34		
9					*				1.69			1.36		
10					*				1.66			1.33		
11					*				1.73			1.27		
12					*				1.74			1.31		
13					*				1.65			1.32		
14					*				1.71			1.24		
15					*				1.90			1.55		

* Automatically maintained between 1.3 - 1.4 mg/L

** Constitutes total chlorine dosage applied for pre and post-chlorination

TABLE 3.2 (cont'd)

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION Cl2 Dem.	Cl2 Dos.	NH3	SO2	RESIDUAL Cl2 Free	RESIDUAL Cl2 Comb	RESIDUAL Cl2 Total	POST-CHLORINATION Cl2 Dem.	Cl2 Dos.**	NH3	SO2	RESIDUAL Cl2 Free	RESIDUAL Cl2 Comb	RESIDUAL Cl2 Total
16					*				1.62			1.28		
17					*				1.84			1.45		
18					*				1.75			1.31		
19					*				1.94			1.30		
20					*				1.60			1.24		
21					*				1.66			1.18		
22					*				1.69			1.18		
23					*				1.99			1.32		
24					*				1.66			1.30		
25					*				1.80			1.27		
26					*				1.84			1.52		
27					*				1.73			1.33		
28					*				1.77			1.37		
29					*				1.75			1.42		
30					*				1.63			1.16		
31					*				1.82			1.39		

TABLE 3.2: DISINFECTION PROFILE (OCT/1984)-BARE POINT

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION							POST-CHLORINATION						
	Cl2		NH3	SO2	RESIDUAL Cl2			Cl2		NH3	SO2	RESIDUAL Cl2		
	Dem.	Dos.			Free	Comb	Total	Dem.	Dos.**			Free	Comb	Total
1					*				1.57			1.28		
2					*				1.64			1.23		
3					*				1.73			1.29		
4					*				1.80			1.41		
5					*				1.69			1.33		
6					*				1.73			1.32		
7					*				1.52			1.34		
8					*				1.73			1.39		
9					*				1.84			1.49		
10					*				1.64			1.26		
11					*				1.65			1.27		
12					*				1.61			1.26		
13					*				1.71			1.30		
14					*				1.67			1.31		
15					*				1.88			1.34		

* Automatically maintained between 1.3 - 1.4 mg/L

** Constitutes total chlorine dosage applied for pre and post-chlorination

TABLE 3.2 (cont'd)

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION Cl2 Dem.	Cl2 Dos.	NH3	SO2	RESIDUAL Cl2 Free	Comb	Total	POST-CHLORINATION Cl2 Dem.	Cl2 Dos.**	NH3	SO2	RESIDUAL Cl2 Free	Comb	Total
16					*				1.79			1.40		
17					*				1.89			1.33		
18					*				1.87			1.41		
19					*				1.72			1.38		
20					*				1.78			1.31		
21					*				1.73			1.30		
22					*				1.81			1.43		
23					*				1.76			1.36		
24					*				1.58			1.35		
25					*				1.77			1.36		
26					*				1.77			1.32		
27					*				1.71			1.22		
28					*				1.62			1.22		
29					*				1.74			1.34		
30					*				1.93			1.35		
31					*				1.91			1.11		

TABLE 3.2: DISINFECTION PROFILE (JAN/1985)-BARE POINT
MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION Cl2 Dem.	Cl2 Dos.	NH3	SO2	RESIDUAL Cl2 Free	Comb	Total	POST-CHLORINATION Cl2 Dem.	Cl2 Dos.**	NH3	SO2	RESIDUAL Cl2 Free	Comb	Total
1					*				1.87			1.38		
2					*				1.89			1.43		
3					*				1.68			1.29		
4					*				1.66			1.23		
5					*				1.65			1.26		
6					*				1.76			1.24		
7					*				1.80			1.27		
8					*				1.90			1.35		
9					*				1.94			1.34		
10					*				1.69			1.36		
11					*				1.66			1.34		
12					*				1.69			1.34		
13					*				1.82			1.36		
14					*				1.92			1.44		
15					*				1.80			1.50		

* Automatically maintained between 1.3 - 1.4 mg/L

** Constitutes total chlorine dosage applied for pre and post-chlorination

TABLE 3.2 (cont'd)

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION Cl2 Dem.	Cl2 Dos.	NH3	SO2	RESIDUAL Cl2 Free	Comb	Total	POST-CHLORINATION Cl2 Dem.	Cl2 Dos.**	NH3	SO2	RESIDUAL Cl2 Free	Comb	Total
16					*				1.71			1.30		
17					*				1.62			1.28		
18					*				1.62			1.26		
19					*				1.73			1.31		
20					*				1.73			1.38		
21					*				1.76			1.36		
22					*				1.68			1.32		
23					*				1.75			1.28		
24					*				1.84			1.37		
25					*				1.90			1.30		
26					*				1.64			1.33		
27					*				1.78			1.29		
28					*				1.67			1.31		
29					*				1.70			1.31		
30					*				1.63			1.30		
31					*				1.68			1.24		

TABLE 3.2: DISINFECTION PROFILE (APRIL/1985)-BARE POINT

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION Cl2 Dem.	PRE-CHLORINATION Cl2 Dos.	PRE-CHLORINATION NH3	PRE-CHLORINATION SO2	PRE-CHLORINATION RESIDUAL Cl2 Free	PRE-CHLORINATION RESIDUAL Cl2 Comb	PRE-CHLORINATION RESIDUAL Cl2 Total	POST-CHLORINATION Cl2 Dem.	POST-CHLORINATION Cl2 Dos.**	POST-CHLORINATION NH3	POST-CHLORINATION SO2	POST-CHLORINATION RESIDUAL Cl2 Free	POST-CHLORINATION RESIDUAL Cl2 Comb	POST-CHLORINATION RESIDUAL Cl2 Total
1					*				1.33			1.26		
2					*				1.49			1.30		
3					*				1.43			1.45		
4					*				1.33			1.33		
5					*				1.41			1.21		
6					*				1.48			1.31		
7					*				1.41			1.32		
8					*				1.56			1.27		
9					*				1.38			1.31		
10					*				1.37			1.31		
11					*				1.30			1.26		
12					*				1.35			1.34		
13					*				1.41			1.35		
14					*				1.32			1.25		
15					*				1.43			1.30		

* Automatically maintained between 1.3 - 1.4 mg/L

** Constitutes total chlorine dosage applied for pre and post-chlorination

TABLE 3.2 (cont'd)

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION Cl2 Dem.	PRE-CHLORINATION Cl2 Dos.	PRE-CHLORINATION NH3	PRE-CHLORINATION SO2	PRE-CHLORINATION RESIDUAL Cl2 Free	PRE-CHLORINATION RESIDUAL Cl2 Comb	PRE-CHLORINATION RESIDUAL Cl2 Total	POST-CHLORINATION Cl2 Dem.	POST-CHLORINATION Cl2 Dos.**	POST-CHLORINATION NH3	POST-CHLORINATION SO2	POST-CHLORINATION RESIDUAL Cl2 Free	POST-CHLORINATION RESIDUAL Cl2 Comb	POST-CHLORINATION RESIDUAL Cl2 Total
16					*				1.40			1.27		
17					*				1.45			1.19		
18					*				1.55			1.11		
19					*				1.46			1.27		
20					*				1.41			1.26		
21					*				1.48			1.28		
22					*				1.53			1.32		
23					*				1.54			1.27		
24					*				1.55			1.33		
25					*				1.61			1.32		
26					*				1.60			1.23		
27					*				1.57			1.20		
28					*				1.60			1.29		
29					*				1.61			1.32		
30					*				1.46			1.27		

TABLE 3.2: DISINFECTION PROFILE (JULY/1985)-BARE POINT

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION Cl2 Dem.	Cl2 Dos.	NH3	SO2	RESIDUAL Cl2 Free	Comb	Total	POST-CHLORINATION Cl2 Dem.	Cl2 Dos.**	NH3	SO2	RESIDUAL Cl2 Free	Comb	Total
1					*				1.66			1.25		
2					*				1.67			1.28		
3					*				1.75			1.26		
4					*				1.77			1.22		
5					*				1.76			1.29		
6					*				1.66			1.20		
7					*				1.92			1.19		
8					*				1.79			1.27		
9					*				1.78			1.34		
10					*				1.81			1.34		
11					*				1.74			1.37		
12					*				1.76			1.34		
13					*				1.81			1.28		
14					*				1.74			1.20		
15					*				1.82			1.24		

* Automatically maintained between 1.3 - 1.4 mg/L

** Constitutes total chlorine dosage applied for pre and post-chlorination

TABLE 3.2 (cont'd)

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION Cl2 Dem.	Cl2 Dos.	NH3	SO2	RESIDUAL Cl2 Free	Comb	Total	POST-CHLORINATION Cl2 Dem.	Cl2 Dos.**	NH3	SO2	RESIDUAL Cl2 Free	Comb	Total
16					*				1.88			1.34		
17					*				1.67			1.23		
18					*				1.98			1.25		
19					*				2.04			1.43		
20					*				2.12			1.37		
21					*				1.82			1.33		
22					*				1.69			1.30		
23					*				2.31			1.26		
24					*				2.11			1.24		
25					*				1.99			1.16		
26					*				1.77			1.23		
27					*				1.74			1.34		
28					*				1.88			1.36		
29					*				1.98			1.43		
30					*				1.51			1.28		
31					*				1.64			1.27		

TABLE 3.2: DISINFECTION PROFILE (OCT/1985)-BARE POINT

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION							POST-CHLORINATION						
	Cl2		NH3	SO2	RESIDUAL Cl2			Cl2		NH3	SO2	RESIDUAL Cl2		
	Dem.	Dos.			Free	Comb	Total	Dem.	Dos.**			Free	Comb	Total
1					*				1.83			1.34		
2					*				1.74			1.25		
3					*				1.91			1.19		
4					*				1.83			1.24		
5					*				1.83			1.32		
6					*				1.64			1.36		
7					*				1.68			1.43		
8					*				1.73			1.26		
9					*				1.71			1.38		
10					*				1.63			1.29		
11					*				1.72			1.20		
12					*				1.95			1.23		
13					*				1.68			1.25		
14					*				1.69			1.27		
15					*				1.84			1.33		

* Automatically maintained between 1.3 - 1.4 mg/L

** Constitutes total chlorine dosage applied for pre and post-chlorination

TABLE 3.2 (cont'd)

MOE WPOS PROTOCOL

	PRE-CHLORINATION							POST-CHLORINATION						
DATE	Cl2		NH3	SO2	RESIDUAL Cl2			Cl2		NH3	SO2	RESIDUAL Cl2		
	Dem.	Dos.			Free	Comb	Total	Dem.	Dos.**			Free	Comb	Total
16					*				1.89			1.34		
17					*				1.94			1.33		
18					*				1.77			1.40		
19					*				1.65			1.21		
20					*				2.07			1.19		
21					*				2.09			1.26		
22					*				1.75			1.30		
23					*				1.67			1.30		
24					*				1.77			1.18		
25					*				1.81			1.21		
26					*				1.65			1.20		
27					*				1.65			1.23		
28					*				1.63			1.32		
29					*				1.79			1.25		
30					*				1.79			1.24		
31					*				2.15			1.18		

TABLE 3.2: DISINFECTION PROFILE (JAN/1986)-BARE POINT

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION Cl2 Dem.	Cl2 Dos.	NH3	SO2	RESIDUAL Cl2 Free	Comb	Total	POST-CHLORINATION Cl2 Dem.	Dos.**	NH3	SO2	RESIDUAL Cl2 Free	Comb	Total
1					*				1.50			1.37		
2					*				1.49			1.29		
3					*				1.59			1.32		
4					*				1.47			1.42		
5					*				1.45			1.34		
6					*				1.59			1.32		
7					*				1.58			1.36		
8					*				1.49			1.30		
9					*				1.56			1.35		
10					*				1.46			1.23		
11					*				1.40			1.22		
12					*				1.50			1.27		
13					*				1.52			1.24		
14					*				1.63			1.35		
15					*				1.38			1.27		

* Automatically maintained between 1.3 - 1.4 mg/L

** Constitutes total chlorine dosage applied for pre and post-chlorination

TABLE 3.2 (cont'd)

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION Cl2 Dem.	Cl2 Dos.	NH3	SO2	RESIDUAL Cl2 Free	Comb	Total	POST-CHLORINATION Cl2 Dem.	Dos.**	NH3	SO2	RESIDUAL Cl2 Free	Comb	Total
16					*				1.79			1.36		
17					*				1.52			1.29		
18					*				1.96			1.19		
19					*				1.76			1.26		
20					*				1.54			1.28		
21					*				1.58			1.28		
22					*				1.36			1.32		
23					*				1.33			1.22		
24					*				1.48			1.19		
25					*				1.35			1.22		
26					*				1.40			1.27		
27					*				1.59			1.36		
28					*				1.56			1.34		
29					*				1.43			1.24		
30					*				1.39			1.27		
31					*				1.52			1.31		

TABLE 3.2: DISINFECTION PROFILE (APRIL/1986)-BARE POINT

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION							POST-CHLORINATION						
	Cl2		NH3	SO2	RESIDUAL Cl2			Cl2		NH3	SO2	RESIDUAL Cl2		
	Dem.	Dos.			Free	Comb	Total	Dem.	Dos.**			Free	Comb	Total
1					*				1.53			1.29		
2					*				1.53			1.37		
3					*				1.62			1.34		
4					*				1.61			1.33		
5					*				1.39			1.30		
6					*				1.46			1.31		
7					*				1.64			1.31		
8					*				1.56			1.30		
9					*				1.46			1.24		
10					*				1.52			1.27		
11					*				1.48			1.27		
12					*				1.65			1.27		
13					*				1.64			1.30		
14					*				1.62			1.31		
15					*				1.56			1.30		

* Automatically maintained between 1.3 - 1.4 mg/L

** Constitutes total chlorine dosage applied for pre and post-chlorination

TABLE 3.2 (cont'd)

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION							POST-CHLORINATION						
	Cl_2		NH_3	SO_2	RESIDUAL Cl_2			Cl_2		NH_3	SO_2	RESIDUAL Cl_2		
	Dem.	Dos.			Free	Comb	Total	Dem.	Dos.**			Free	Comb	Total
16					*				1.46			1.28		
17					*				1.48			1.29		
18					*				1.51			1.26		
19					*				1.42			1.26		
20					*				1.58			1.30		
21					*				1.75			1.33		
22					*				1.65			1.34		
23					*				1.68			1.24		
24					*				1.65			1.23		
25					*				1.67			1.28		
26					*				1.52			1.29		
27					*				1.64			1.34		
28					*				1.48			1.28		
29					*				1.65			1.25		
30					*				1.51			1.22		

TABLE 3.2: DISINFECTION PROFILE (JULY/1986)-BARE POINT
MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION							POST-CHLORINATION						
	Cl2		NH3	SO2	RESIDUAL Cl2			Cl2		NH3	SO2	RESIDUAL Cl2		
	Dem.	Dos.			Free	Comb	Total	Dem.	Dos.**			Free	Comb	Total
1					*				1.75			1.25		
2					*				1.74			1.31		
3					*				1.69			1.27		
4					*				1.23			1.25		
5					*				1.72			1.24		
6					*				1.86			1.27		
7					*				2.01			1.43		
8					*				1.55			1.31		
9					*				1.73			1.21		
10					*				1.64			1.12		
11					*				1.56			1.12		
12					*				1.74			1.27		
13					*				1.71			1.21		
14					*				1.84			1.33		
15					*				1.76			1.28		

* Automatically maintained between 1.3 - 1.4 mg/L

** Constitutes total chlorine dosage applied for pre and post-chlorination

TABLE 3.2 (cont'd)

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION Cl2 Dem.	Cl2 Dos.	NH3	SO2	RESIDUAL Cl2 Free	Comb	Total	POST-CHLORINATION Cl2 Dem.	Cl2 Dos.**	NH3	SO2	RESIDUAL Cl2 Free	Comb	Total
16					*				1.78			1.46		
17					*				1.65			1.26		
18					*				1.60			1.27		
19					*				1.66			1.26		
20					*				1.76			1.36		
21					*				1.65			1.27		
22					*				1.68			1.20		
23					*				1.61			1.27		
24					*				1.89			1.37		
25					*				1.86			1.35		
26					*				1.69			1.18		
27					*				2.06			1.33		
28					*				1.85			1.34		
29					*				1.80			1.40		
30					*				1.67			1.34		
31					*				1.85			1.18		

TABLE 3.2: DISINFECTION PROFILE (OCT/1986)-BARE POINT

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION							POST-CHLORINATION						
	Cl2		NH3	SO2	RESIDUAL Cl2			Cl2		NH3	SO2	RESIDUAL Cl2		
	Dem.	Dos.			Free	Comb	Total	Dem.	Dos.**			Free	Comb	Total
1					*				1.49			1.33		
2					*				1.72			1.33		
3					*				1.73			1.23		
4					*				1.76			1.34		
5					*				1.79			1.39		
6					*				1.75			1.45		
7					*				1.68			1.37		
8					*				1.54			1.25		
9					*				1.56			1.25		
10					*				1.88			1.28		
11					*				1.63			1.32		
12					*				1.65			1.34		
13					*				1.80			1.41		
14					*				1.73			1.35		
15					*				1.64			1.35		

* Automatically maintained between 1.3 - 1.4 mg/L

** Constitutes total chlorine dosage applied for pre and post-chlorination

TABLE 3.2 (cont'd)

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION Cl2 Dem.	PRE-CHLORINATION Cl2 Dos.	PRE-CHLORINATION NH3	PRE-CHLORINATION SO2	PRE-CHLORINATION RESIDUAL Cl2 Free	PRE-CHLORINATION RESIDUAL Cl2 Comb	PRE-CHLORINATION RESIDUAL Cl2 Total	POST-CHLORINATION Cl2 Dem.	POST-CHLORINATION Cl2 Dos.**	POST-CHLORINATION NH3	POST-CHLORINATION SO2	POST-CHLORINATION RESIDUAL Cl2 Free	POST-CHLORINATION RESIDUAL Cl2 Comb	POST-CHLORINATION RESIDUAL Cl2 Total
16					*				1.48			1.26		
17					*				1.61			1.26		
18					*				1.77			1.19		
19					*				1.89			1.27		
20					*				1.80			1.22		
21					*				1.70			1.12		
22					*				2.23			1.10		
23					*				2.01			1.28		
24					*				1.96			1.39		
25					*				1.81			1.33		
26					*				1.94			1.32		
27					*				1.82			1.38		
28					*				1.87			1.35		
29					*				1.90			1.20		
30					*				1.71			1.35		
31					*				1.81			1.26		

TABLE 4

WATER PLANT OPTIMIZATION STUDY
"WATER QUALITY SUMMARY"

TABLE 4.0

WPOS

PLANT BARE POINT WATER QUALITY - 4-YEAR SUMMARY ( )

GENERAL CHEMISTRY		1986 MAX	1986 MIN	1986 AVE	1985 MAX	1985 MIN	1985 AVE	1984 MAX	1984 MIN	1984 AVE	1983 MAX	1983 MIN	1983 AVE	DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
GENERAL CHEMISTRY															
ALKALINITY	R	46.59	46.2	46.57	48.80	44.00	45.78	44.35	40.0	44.46	45.74	43.24	45.70	0.2	
mg/L	T	39.08	37.1	44.44	47.00	37.20	41.58	38.59	32.6	39.9	40.23	37.50	40.34	mg/L	
AMMONIUM TOTAL	R													0.05	
mg/L	T													mg/L	
CALCIUM	R													0.1	
mg/L	T													mg/L	
CHLORIDE	R	1.87	1.50	1.66	2.0	1.15	1.69	3.3	1.4	1.8	6.8	1.5	2.2	0.2	250
mg/L	T													mg/L	mg/L
COLOUR TCU	R	4.0	2.0	3.07	6.0	1.60	3.96	10	2	5.28	9.0	4.5	5.8	0.5	5
	T	1.0	1.0	1.0	2.5	1.00	1.29	2.65	< 1	1.27	5.0	1.0	1.5	TCU	TCU
CONDUCTIVITY	R	103	97	99.74	102.0	95.33	98.59	103.5	97.5	101.7	106	99	102.1	0.01	
umho/cm	T	107.6	101	103.7	106.0	100.5	103.68	109	102	105.8	103	111	106.6	UMHO/CM	
FIELD CHLORINE (COMBINED)	R													0.1	
mg/L	T													mg/L	
FIELD CHLORINE (FREE)	R													0.1	
mg/L	T													mg/L	
FIELD CHLORINE (TOTAL)	R													0.1	
mg/L	T													mg/L	
FIELD PH	R													0.2	
	T														

TABLE 4. Cont'd

PLANT BARE POINT

WPOS
WATER QUALITY - 4-YEAR SUMMARY (   )

GENERAL CHEMISTRY (Cont'd)		1986			1985			1984			1983			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
FIELD TEMPERATURE	R	16.00	4.50	7.98	18.00	4.50	8.36	13.19	4.69	8.16	13.2	4.19	3.25		
°C	T														
FIELD TURBIDITY	R														1 FTU
FTU	T														
FLUORIDE	R													0.01	2.4
mg/L	T													mg/L	mg/L
HARDNESS	R	47.91	45.63	46.85	52.00	38.00	46.32	49.6	43.1	46.39	47.0	42.7	45.7	0.5	
mg/L	T	48.23	45.93	46.80	52.00	36.00	47.43	48.6	36.82	44.72	47.1	41.8	45.2	mg/L	
MAGNESIUM	R													0.05	
mg/L	T													mg/L	c
NITRATE	R							0.32	0.25	0.29	0.39	0.27	0.30	0.05	10 mg/L
mg/L	T										.002	.001	.002	mg/L	as N
NITRITE	R							.002	.001	.001				0.005	1 mg/L
mg/L	T													mg/L	as N
NITROGEN TOTAL KJELDAHL	R							0.21	0.12	0.15	1.40	0.12	0.35	0.1	0.15
mg/L	T													mg/L	mg/L *
PH	R	7.8	7.34	7.67	7.82	7.56	7.69	7.90	7.35	7.76	7.13	7.69	7.51		
	T	7.32	7.13	7.21	7.38	7.05	7.20	7.35	6.94	7.16	7.14	6.94	7.04		
PHOSPHORUS FILTERED REACTIVE	R							0.002	.001	.001	.015	.004	.003	0.01	
mg/L	T													mg/L	

TABLE 4 Cont'd

MPOS

PLANT BARE POINT WATER QUALITY - 4-YEAR SUMMARY ( )

GENERAL CHEMISTRY (Cont'd)		1986 MAX	1986 MIN	1986 AVE	1985 MAX	1985 MIN	1985 AVE	1984 MAX	1984 MIN	1984 AVE	1983 MAX	1983 MIN	1983 AVE	DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
PHOSPHORUS TOTAL	R							0.007	0.004	0.006	0.015	.004	.007	0.01	
mg/L	T													mg/L	
SODIUM	R													0.1	
mg/L	T													mg/L	
TOTAL SOLIDS	R													1	
mg/L	T													mg/L	
TURBIDITY	R	1.80	0.28	0.56	1.50	0.25	0.59	0.88	0.33	0.61	0.82	0.36	0.55	0.01	1
FTU	T	0.45	0.07	0.11	0.52	0.05	0.11	0.13	0.05	0.10	0.19	0.09	0.14	FTU	FTU
METALS															
ALUMINUM	R	.011	.003	.005	0.008	0.001	0.003	.007	.004	.006	.013	.001	.005	0.003	
mg/L	T	0.17	.007	.023	0.030	0.008	0.018	0.115	.007	.032	.021	.005	0.010	mg/L	
ARSENIC	R													0.001	0.05
mg/L	T													mg/L	mg/L
BARIUM	R													0.001	1
mg/L	T													mg/L	mg/L
BERYLLIUM	R													0.001	
mg/L	T													mg/L	
BORON	R													0.02	5
mg/L	T													mg/L	mg/L
CADMIUM	R													0.0003	0.005
mg/L	T													mg/L	mg/L

TABLE 4 Cont'd

MPOS

PLANT BARE POINT WATER QUALITY - 4-YEAR SUMMARY ( )

METALS (Cont'd)			1986 MAX	1986 MIN	1986 AVE	1985 MAX	1985 MIN	1985 AVE	1984 MAX	1984 MIN	1984 AVE	1983 MAX	1983 MIN	1983 AVE	DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
CHROMIUM		R													0.001	0.05
	mg/L	T													mg/L	mg/L
COBALT		R													0.001	
	mg/L	T													mg/L	
COPPER		R													0.001	1
	mg/L	T													mg/L	mg/L
CYANIDE		R													0.001	0.2
	mg/L	T													mg/L	mg/L
IRON		R	0.10	.05	.06	0.075	<0.05	0.05	0.10	.05	.06	0.08	.05	0.06	0.002	0.3
	mg/L	T	0.06	.05	.05	0.05	<0.05	0.05	.37	.05	.10	.05	.05	0.05	mg/L	mg/L c
LEAD	mg/L	R													0.003	0.05
		T													mg/L	mg/L
MANGANESE		R													0.001	0.05
	mg/L	T													mg/L	mg/L
MOLYBDENUM		R													0.001	
	mg/L	T													mg/L	
MERCURY		R													0.01	1
	ug/L	T													ug/L	ug/L
NICKEL		R													0.002	
	mg/L	T													mg/L	

TABLE 4 Cont'd

WPOS

PLANT BARE POINT WATER QUALITY - 4-YEAR SUMMARY ( )

METALS (Cont'd)		1986			1985			1984			1983			OWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
SELENIUM	R													0.001	0.01
mg/L	T													mg/L	mg/L
STRONTIUM	R													0.001	
mg/L	T													mg/L	
TIN	R														
(no units available)	T														
URANIUM	R													0.002	.02
mg/L	T													mg/L	mg/L t
VANADIUM	R													0.001	
mg/L	T													mg/L	
ZINC	R													0.001	5
mg/L	T													mg/L	mg/L h
PURGEABLES															
BENZENE	R													1	10
ug/L	T													ug/L	ug/L h
BROMOFORM	R													1	350
ug/L	T													ug/L	ug/L ++
CARBON TETRACHLORIDE	R							0	0	0				1	3
ug/L	T							0	0	0				ug/L	ug/L h
CHLOROBENZENE	R													1	100-300
ug/L	T													ng/L	ng/L h*

TABLE 4 Cont'd

WPOS

PLANT BARE POINT WATER QUALITY - 4-YEAR SUMMARY ( )

PURGEABLES (Cont'd)		1986 MAX	1986 MIN	1986 AVE	1985 MAX	1985 MIN	1985 AVE	1984 MAX	1984 MIN	1984 AVE	1983 MAX	1983 MIN	1983 AVE	DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
CHLORODIBROMOMETHANE	R	0	0	0				0	0	0	0	0	0	1	350
ug/L	T	0	0	0.50				0	0	0	0	0	0	ug/L	ug/L ++
CHLOROFORM	R	0.0	0.0	0				0	0	0	0	0	0	1	350
ug/L	T	146	35	78				31	0	20.3	180	116	137	ug/L	ug/L ++
1,2-DICHLOROBENZENE	R													1	400
ug/L	T													ug/L	ug/L e
1,3-DICHLOROBENZENE	R													1	400
ug/L	T													ug/L	ug/L e
1,4-DICHLOROBENZENE	R													1	400
ug/L	T													ug/L	ug/L e
DICHLOROBROMOMETHANE	R	0	0	0				0	0	0	0	0	0	1	350
ug/L	T	23	5	9.5				0	0	0	5	3	3.5	ug/L	ug/L ++
1,1-DICHLOROETHANE	R													1	
ug/L	T													ug/L	
1,2-DICHLOROETHANE	R													1	10
ug/L	T													ug/L	ug/L h
1,1-DICHLOROETHYLENE	R													1	.3
ug/L	T													ug/L	ug/L h
T,1,2-DICHLOROETHYLENE	R													1	
ug/L	T													ug/L	

TABLE 4 Cont'd

WPOS

PLANT BARE POINT WATER QUALITY - 4-YEAR SUMMARY ( )

PURGEABLES (Cont'd)		1986			1985			1984			1983			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
DICHLOROMETHANE	R													5	40
ug/L	T													ug/L	ug/L c
1,2 DICHLOROPROPANE	R													1	
ug/L	T													ug/L	
ETHYLBENZENE	R													1	1400
ug/L	T													ug/L	ug/L e
ETHYLENE DIBROMIDE	R														
ug/L	T														
M-XYLENE	R													1	620
ug/L	T													ug/L	ug/L c
O-XYLENE	R													1 ug/L	620
ug/L	T														ug/L c
P-XYLENE	R													1	620
ug/L	T													ug/L	ug/L c
TOLUENE	R													1	100
ug/L	T													ug/L	ug/L c
1,1,2,2-TETRACHLOROETHANE	R													1	1.7
ug/L	T													ug/L	ug/L e
TETRACHLOROETHYLENE	R													1	10
ug/L	T													ug/L	ug/L h

TABLE 4 Cont'd

MPOS

PLANT BARE POINT WATER QUALITY - 4-YEAR SUMMARY ( )

PURGEABLES (Cont'd)		1986 MAX	1986 MIN	1986 AVE	1985 MAX	1985 MIN	1985 AVE	1984 MAX	1984 MIN	1984 AVE	1983 MAX	1983 MIN	1983 AVE	DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
1,1,1-TRICHLOROETHANE	R													1	1000
ug/L	T													ug/L	ug/L c
1,1,2-TRICHLOROETHANE	R													1	6
ug/L	T													ug/L	ug/L e
TRICHLOROETHYLENE	R													1	30
ug/L	T													ug/L	ug/L h
TOTAL TRIHALOMETHANES	R	0	0	0				0	0	0				3	350
ug/L	T	171	40	88				35	0	23.2				ug/L	ug/L ++
TRIFLUOROCHLOROTOLUENE	R													1	
ug/L	T													ug/L	
ORGANOCHLORINES															
ALDRIN	R													1	700
ng/L	T													ng/L	ng/L **
ALPHA BHC	R													1	700
ng/L	T													ng/L	ng/L c
ALPHA CHLORDANE	R													2	700
ng/L	T													ng/L	ng/L ***
BETA BHC	R													1	300
ng/L	T													ng/L	ng/L c
DIELDRIN	R													2	700
ng/L	T													ng/L	ng/L **

TABLE 4 Cont'd

WPOS

PLANT BARE POINT WATER QUALITY - 4-YEAR SUMMARY ( )

ORGANOCHLORINES (Cont'd)		1986			1985			1984			1983			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
ENDRIN ng/L	R													4	200
	T													ng/L	ng/L
GAMMA CHLORDANE ng/L	R													2	700
	T													ng/L	ng/L ***
HEPTACHLOR EPOXIDE ng/L	R													1	3000 +++
	T													ng/L	ng/L
HEPTACHLOR ng/L	R													1	3000
	T													ng/L	ng/L +++
HEXACHLOROBENZENE ng/L	R													1	10
	T													ng/L	ng/L h
HEXACHLOROBUTADIENE ug/L	R														
	T														
HEXACHLOROETHANE ng/L	R													1	19000
	T													ng/L	ng/L e
LINDANE ng/L	R													1	4000
	T													ng/L	ng/L
METHOXYCHLOR ng/L	R													5	100000
	T													ng/L	ng/L
MIREX ng/L	R													5	
	T													ng/L	

TABLE 4 Cont'd

WPOS

PLANT BARE POINT WATER QUALITY - 4-YEAR SUMMARY ( )

ORGANOCHLORINES (Cont'd)		1986			1985			1984			1983			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
OCTACHLOROSTYRENE	R													1	
ng/L	T													ng/L	
O,P-DDT	R													5	30000
ng/L	T													ng/L	ng/L d
OXYCHLORDANE	R													2	
ng/L	T													ng/L	
PCB TOTAL	R													20	3000
ng/L	T													ng/L	ng/L t
PENTACHLOROBENZENE	R													1	74000
ng/L	T													ng/L	ng/L •
P,P-DDD	R													5	d
ng/L	T													ng/L	
P,P-DDE	R													1	d
ng/L	T													ng/L	
P,P-DDT	R													5	d
ng/L	T													ng/L	
1,2,3,4-TETRACHLOROBENZENE	R													1	
ng/L	T													ng/L	
1,2,3,5-TETRACHLOROBENZENE	R													1	
ng/L	T													ng/L	

TABLE 4 Cont'd

MPOS

PLANT BARE POINT WATER QUALITY - 4-YEAR SUMMARY ( )

ORGANOCHLORINES (Cont'd)		1986			1985			1984			1983			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
1,2,4,5-TETRACHLOROBENZENE	R													1	38000
ng/L	T													ng/L	ng/L •
THIODAN I	R													2	74000
ng/L	T													ng/L	ng/L ••
THIODAN II	R													4	74000
ng/L	T													ng/L	ng/L •a
THIODAN SULPHATE	R													4	
ng/L	T													ng/L	
TOXAPHENE	R														
(no units available)	T														
1,2,3-TRICHLOROBENZENE	R													5	10000
ng/L	T													ng/L	ng/L y
1,2,4-TRICHLOROBENZENE	R													5	15000
ng/L	T													ng/L	ng/L y
1,3,5-TRICHLOROBENZENE	R													5	10000
ng/L	T													ng/L	ng/L y
2,3,6-TRICHLOROTOLUENE	R													5	
ng/L	T													ng/L	
2,4,5-TRICHLOROTOLUENE	R													5	10000
ng/L	T													ng/L	ng/L g

TABLE 4 Cont'd

WPOS

PLANT BARE POINT WATER QUALITY - 4-YEAR SUMMARY ( )

ORGANOCHLORINES (Cont'd)		1986			1985			1984			1983			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
2,6,A-TRICHLOROTOLUENE mg/L	R T													5 ng/L	
TRIAZINES															
ALACHLOR ng/L	R T														
AMETRINE ng/L	R T													50 ng/L	
ATRATONE ng/L	R T														
ATRAZINE ng/L	R T													50 ng/L	46000 ng/L !
BLADEX ng/L	R T													100 ng/L	10000 ng/L !
METOLACHLOR ng/L	R T														
PROMETONE ng/L	R T													50 ng/L	
PROMETRYNE ng/L	R T													50 ng/L	1000 ng/L !
PROPAZINE ng/L	R T													50 ng/L	

TABLE 4 Cont'd

MPOS

PLANT BARE POINT WATER QUALITY - 4-YEAR SUMMARY ( )

TRIAZINES (Cont'd)		1986			1985			1984			1983			OWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
SENCOR	R													100	
ng/L	T													ng/L	
SIMAZINE	R													50	10000
ng/L	T													ng/L	ng/L I
SPECIAL PESTICIDES															
2,4-D	R													100	100000
ng/L	T													ng/L	ng/L
2,4-D BUTYRIC ACID	R													200	18000
ng/L	T													ng/L	ng/L I
DICAMBA	R													100	87000
ng/L	T													ng/L	ng/L I
PENTACHLOROPHENOL	R													50	10000
ng/L	T													ng/L	ng/L h
PICLORAM	R													100	
ng/L	T													ng/L	
2,4-D PROPIONIC ACID	R													100	
ng/L	T													ng/L	
SILVEX	R													50	10000
ng/L	T													ng/L	ng/L
2,4,5-T	R													50	
ng/L	T													ng/L	

SPECIAL PESTICIDES (Cont'd)		1986 MAX	1986 MIN	1986 AVE	1985 MAX	1985 MIN	1985 AVE	1984 MAX	1984 MIN	1984 AVE	1983 MAX	1983 MIN	1983 AVE	DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
,3,4,5-TETRACHLOROPHENOL	R													50	
ng/L	T													ng/L	
,3,5,6-TETRACHLOROPHENOL	R													50	
ng/L	T													ng/L	
,3,4-TRICHLOROPHENOL	R													100	
ng/L	T													ng/L	
,4,5-TRICHLOROPHENOL	R													50	
ng/L	T													ng/L	
,4,6-TRICHLOROPHENOL	R													50	10000
ng/L	T													ng/L	ng/L h
RGANOPHOSPHOROUS PESTICIDES															
IAZINON	R													50	14000
ng/L	T													ng/L	ng/L
ICHLOROVOS	R														
ng/L	T														
URSBAN	R														
ng/L	T														
THION	R														
ng/L	T														
UTHION	R														
ng/L	T														

TABLE 4 Cont'd

WPOS

PLANT BARE POINT WATER QUALITY - 4-YEAR SUMMARY ( )

ORGANOPHOSPHOROUS PESTICIDES (Cont'd)		19 86			19 85			19 84			19 83			OWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
MALATHION	R														
ng/L	T														
METHYLPARATHION	R													50	7000
ng/L	T													ng/L	ng/L
METHYLTRITHION	R														
ng/L	T														
MEVINPHOS	R														
ng/L	T														
PARATHION	R													50	35000
ng/L	T													ng/L	ng/L
PHORBATE	R														
ng/L	T														
RELDAN	R														
ng/L	T														
RONNEL	R														
ng/L	T														
MASS SPEC.															
DI-N-BUTYL PHTHALATE	R													0.1	34000
ug/L	T													ug/L	ug/L

TABLE 4 Cont'd

WPOS

PLANT BARE POINT WATER QUALITY - 4-YEAR SUMMARY ( ).

MASS SPEC. (Cont'd)		1986			1985			1984			1983			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
N-DICHLOROMETHYLENE- PENTACHLOROANALINE ug/L	R													0.1 ug/L	
	T														
DIPHENYL ETHER ug/L	R													0.1 ug/L	
	T														
FLUORANTHENE ug/L	R													0.1 ug/L	
	T														
HEXACHLOROPROPENE ug/L	R													0.1 ug/L	
	T														
METHYL PHENANTHRENE ug/L	R													0.1 ug/L	
	T														
NAPHTHALENE ug/L	R													0.1 ug/L	
	T														
PENTACHLOROBUTADIENE ug/L	R													0.1 ug/L	
	T														
PENTACHLOROPROPANE ug/L	R													0.1 ug/L	
	T														
PENTACHLOROPROPENE ug/L	R													0.1 ug/L	
	T														
PYRENE ug/L	R													0.1 ug/L	
	T														

TABLE 4 Cont'd

PLANT BARE POINT

WPOS
WATER QUALITY - 4-YEAR SUMMARY ( )

MASS SPEC. (Cont'd)		1986			1985			1984			1983			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
TETRACHLORBUTANE ug/L	R T													0.1 ug/L	
TETRACHLOROBIPHENYL ug/L	R T													0.1 ug/L	
BACTERIA															
RAW WATER:															
TOTAL COLIFORM MF count/100mL	R														
TOTAL COLIFORM BKGD count/100mL	R														
FECAL COLIFORM MF count/100mL	R													0	0/0.1 mL
STANDARD PLATE COUNT MF count/100mL	R													0	500
TREATED WATER:															
PRESENT/ABSENT TEST	T														
TOTAL COLIFORM BACKGROUND MF count/100mL	T													0	OWDO Bact I

WPOS

PLANT BARE POINT WATER QUALITY - 4-YEAR SUMMARY ( )

BACTERIA (Cont'd)		1986			1985			1984			1983			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
TREATED WATER: (Cont'd)															
FECAL COLIFORM MF count/100mL	T													0	ODWO Bactl
STANDARD PLATE COUNT MF count/100mL	T														
IF PRESENT/ABSENT TEST POSITIVE:															
COLIFORM P/A	T														
FECAL COLIFORM P/A	T														
E. COLI P/A	T														
AROMONAS P/A	T														
STAPH. AUREUS P/A	T														

A /ea

Table A - Footnotes

1 = see individual footnotes for Agency of guideline origin

c = California State Department of Health Action Level

d = OWDO for DDT (contains other isomers such as OPDDT and PPDDT)

e = USEPA ambient guideline

ea = United States Environmental Protection Agency (USEPA) ambient level for endosulfan (contains other isomers)

ep = USEPA proposed maximum contaminant level for drinking water

g = suggested Health and Welfare Canada/Ontario Ministry of the Environment guideline value

h = World Health Organization (WHO) guideline

h* = World Health Organization (WHO) Odour Threshold

mg/L = milligrams per litre, parts per million, (ppm)

ng/L = nanograms per litre, parts per trillion, (ppt)

Presence/Absence = microbiological test to indicate presence or absence of coliform bacteria

R = raw water

T = Treated Drinking Water

t = ODWO interim maximum acceptable concentration, (IMAC)

ug/L = micrograms per litre, parts per billion, (ppb)

y = New York State (Taste and Odour) proposed drinking water guideline

++ = total Trihalomethanes

+++ = combined total: Heptachlor and Heptachlor Epoxide

* = if other than DWSP Detection Limit

** = total of Aldrin and Dieldrin

*** = Chlordane is a mixture of alpha and gamma isomers

I = Ministry of the Environment and Health and Welfare Canada, (IMAC)

TABLE 5

WATER PLANT OPTIMIZATION STUDY
"PARTICULATE COUNTING, SUSPENDED SOLIDS AND ALGAE COUNTS"

TABLE 5.0: ALGAE COUNT

NO DATA AVAILABLE FOR ALGAE COUNTS

MONTH	COUNT				
JAN	Max. Min. Avg. No. Tests				
FEB	Max. Min. Avg. No. Tests				
MAR	Max. Min. Avg. No. Tests				
APR	Max. Min. Avg. No. Tests				
MAY	Max. Min. Avg. No. Tests				
JUN	Max. Min. Avg. No. Tests				

NOTE: Three consecutive years of data are required, beginning on the left with the current year. Document source of information. All units ASU.

TABLE 5.0 (cont'd.)

NO DATA AVAILABLE FOR ALGAE COUNTS

MONTH	COUNT				
JUL	Max. Min. Avg. No. Tests				
AUG	Max. Min. Avg. No. Tests				
SEP	Max. Min. Avg. No. Tests				
OCT	Max. Min. Avg. No. Tests				
NOV	Max. Min. Avg. No. Tests				
DEC	Max. Min. Avg. No. Tests				

NOTE: Three consecutive years of data are required, beginning on the left with the current year. Document source of information. All units ASU.

TABLE 6

WATER PLANT OPTIMIZATION STUDY
"BACTERIOLOGICAL TESTING"

TABLE 6.0: BARE POINT
BACTERIOLOGICAL TESTING (1983)

MOE WPOS PROTOCOL

		TOTAL COLIFORM					FECAL COLIFORM					FECAL STREPTOCOCCUS			
		Absent	1-5	6-100	101-5000	>5000	Absent	1-5	6-10	11-500	>500	Absent	<2	2-50	>50
JAN	R	–	3	1	–	–	–	4	–	–	–	–	3	1	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
FEB	R	–	4	–	–	–	–	4	–	–	–	–	3	1	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
MAR	R	–	4	1	–	–	–	5	–	–	–	–	4	1	–
	T	5	–	–	–	–	5	–	–	–	–	5	–	–	–
APR	R	–	3	–	–	–	–	3	–	–	–	–	2	1	–
	T	3	–	–	–	–	3	–	–	–	–	3	–	–	–
MAY	R	–	3	1	–	–	–	4	–	–	–	–	3	1	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
JUN	R	–	4	–	–	–	–	4	–	–	–	–	3	1	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
JUL	R	–	2	1	–	–	–	3	–	–	–	–	2	1	–
	T	2	–	–	–	–	2	–	–	–	–	2	–	–	–
AUG	R	–	4	1	–	–	–	5	–	–	–	–	4	1	–
	T	5	–	–	–	–	5	–	–	–	–	5	–	–	–
SEP	R	–	3	1	–	–	–	4	–	–	–	–	2	2	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
OCT	R	–	2	2	–	–	–	4	–	–	–	–	2	2	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
NOV	R	–	3	2	–	–	–	5	–	–	–	–	2	3	–
	T	5	–	–	–	–	5	–	–	–	–	5	–	–	–
DEC	R	–	2	2	–	–	–	4	–	–	–	–	2	2	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–

NOTE: All results are for 100 mL samples; tests carried out at MOE Lab
Figures indicate number of tests
R = Raw Water.
T = Treated Water.

TABLE 6.1: BARE POINT
BACTERIOLOGICAL TESTING (1984)

MOE WPOS PROTOCOL

		TOTAL COLIFORM					FECAL COLIFORM					FECAL STREPTOCOCCUS			
		Absent	1-5	6-100	101-5000	>5000	Absent	1-5	6-10	11-500	>500	Absent	<2	2-50	>50
JAN	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	T	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FEB	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	T	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MAR	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	T	-	-	-	-	-	-	-	-	-	-	-	-	-	-
APR	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	T	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MAY	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	T	-	-	-	-	-	-	-	-	-	-	-	-	-	-
JUN	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	T	-	-	-	-	-	-	-	-	-	-	-	-	-	-
JUL	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	T	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AUG	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	T	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SEP	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	T	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OCT	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	T	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NOV	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	T	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DEC	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	T	-	-	-	-	-	-	-	-	-	-	-	-	-	-

NOTE: Data not found

R = Raw Water.
T = Treated Water.

TABLE 6.2: BARE POINT
BACTERIOLOGICAL TESTING (1985)

MOE WPOS PROTOCOL

		TOTAL COLIFORM					FECAL COLIFORM					FECAL STREPTOCOCCUS			
		Absent	1-5	6-100	101-5000	>5000	Absent	1-5	6-10	11-500	>500	Absent	<2	2-50	>50
JAN	R	–	2	1	2	–	–	4	–	1	–	–	3	2	–
	T	5	–	–	–	–	5	–	–	–	–	5	–	–	–
FEB	R	–	4	–	–	–	–	4	–	–	–	–	4	–	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
MAR	R	–	4	–	–	–	–	4	–	–	–	–	4	–	–
	T	5	–	–	–	–	5	–	–	–	–	5	–	–	–
APR	R	–	3	1	–	–	–	4	–	–	–	–	4	–	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
MAY	R	–	3	1	–	–	–	4	–	–	–	–	4	–	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
JUN	R	–	2	2	–	–	–	4	–	–	–	–	4	–	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
JUL	R	–	2	3	–	–	–	5	–	–	–	–	3	2	–
	T	5	–	–	–	–	5	–	–	–	–	5	–	–	–
AUG	R	–	2	2	–	–	–	4	–	–	–	–	3	1	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
SEP	R	–	–	3	1	–	–	4	–	–	–	–	2	2	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
OCT	R	–	–	2	1	–	–	3	–	–	–	–	2	1	–
	T	3	–	–	–	–	3	–	–	–	–	3	–	–	–
NOV	R	–	2	2	–	–	–	4	–	–	–	–	4	–	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
DEC	R	–	1	2	–	–	–	3	–	–	–	–	3	–	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–

NOTE: All results are for 100 mL samples; tests carried out at MOE Lab
Figures indicate number of tests
R = Raw Water.
T = Treated Water.

TABLE 6.3: BARE POINT
BACTERIOLOGICAL TESTING (1986)

MOE WPOS PROTOCOL

		TOTAL COLIFORM					FECAL COLIFORM					FECAL STREPTOCOCCUS			
		Absent	1-5	6-100	101-5000	>5000	Absent	1-5	6-10	11-500	>500	Absent	<2	2-50	>50
JAN	R	–	3	1	–	–	–	4	–	–	–	–	4	–	–
	T	5	–	–	–	–	5	–	–	–	–	5	–	–	–
FEB	R	–	4	–	–	–	–	4	–	–	–	–	4	–	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
MAR	R	–	4	–	–	–	–	4	–	–	–	–	4	–	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
APR	R	–	5	–	–	–	–	5	–	–	–	–	5	–	–
	T	5	–	–	–	–	5	–	–	–	–	5	–	–	–
MAY	R	–	4	–	–	–	–	4	–	–	–	–	4	–	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
JUN	R	–	2	1	–	–	–	3	–	–	–	–	2	1	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
JUL	R	–	2	1	–	–	–	3	–	–	–	–	1	2	–
	T	3	–	–	–	–	3	–	–	–	–	3	–	–	–
AUG	R	–	1	3	–	–	–	4	–	–	–	–	4	–	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
SEP	R	–	1	4	–	–	–	5	–	–	–	–	5	–	–
	T	5	–	–	–	–	5	–	–	–	–	5	–	–	–
OCT	R	–	1	2	1	–	–	4	–	–	–	–	4	–	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
NOV	R	–	1	1	–	–	–	2	–	–	–	–	2	–	–
	T	3	–	–	–	–	3	–	–	–	–	3	–	–	–
DEC	R	–	1	2	–	–	–	3	–	–	–	–	3	–	–
	T	3	–	–	–	–	3	–	–	–	–	3	–	–	–

NOTE: All results are for 100 mL samples; tests carried out at MOE Lab
Figures indicate number of tests
R = Raw Water.
T = Treated Water.

TABLE 7

WATER PLANT OPTIMIZATION STUDY
"ONTARIO DRINKING WATER OBJECTIVES EXCEEDANCE SUMMARY"

TABLE 7.0: ONTARIO DRINKING WATER OBJECTIVES INCLUDING ALUMINUM (TREATED WATER AT PLANT)

DATE	PARAMETER	MEASURED PARAMETER	OBJECTIVE LIMIT
	none exceeded		

NOTE: List health-related parameters which exceed Ontario Drinking Water Objectives

APPENDIX B - DAILY LOG SHEETS

THE CORPORATION OF THE CITY OF THUNDER BAY
PUBLIC WORKS DEPARTMENT

BARE POINT WATER TREATMENT PLANT

DAILY PLANT OPERATORS REPORT

DATE JAN 31 1985

HOURS	LOW LIFT # 1	# 2	# 3	TOTAL FLOW	WET WELL LEVEL	RAW WATER C_{L_2}	TURB.	PH	TEMP.	FLOC COND.	TREATED WATER CLEAR WELL LEVEL	C_{L_2}	SYSTEM PRESS.	TURB.	PH	HIGH LIFT FLOW 1	FLOW 2	FLOW 3	TOTAL	TIME
0100	62			40,000	4.6	1.25	.51	7.75	5'	60	4.1	1.2	770	.07	7.3	20.2	17.5		37,700	13.00
0200	55			38,000	4.7	1.3	.50	7.75	5'	70	4.3	1.25	780	.06	7.25	20	17		37,000	16:00
0300	55			38,000	4.7	1.25	.52	7.75	5'	70	4.5	1.3	780	.06	7.25	20	17		37,000	
0400	55			38,000	4.7	1.3	.51	7.75	5	70	4.7	1.25	780	.06	7.25	20	17		37,200	
0500	55			38,000	4.7	1.25	.52	7.75	5	70	4.9	1.2	785	.06	7.25	20	17		37,000	
0600	55			38,000	4.7	1.25	.53	7.75	5'	70	5.1	1.2	785	.07	7.25	20	17		37,000	
0700	54			38,000	4.8	1.1	.52	7.75	5'	70	2.8	1.2	765	.08	7.25	20.5	18		38,500	1910
0800	57			39000	4.7	1.2	.52	7.7	5°	70	2.9	1.2	765	.08	7.3	20.5	18		38500	1960
0900	58			39000	4.7	1.3	.52	7.7	5°	70	3.0	1.2	760	.07	7.3	20.5	18		38500	0
1000	58			39000	4.7	1.3	.52	7.7	5°	70	3.1	1.2	760	.07	7.3	20.5	18		38500	
1100	58			39000	4.7	1.25	.52	7.7	5°	70	3.2	1.2	760	.07	7.3	20.5	18		38500	
1200	58			39000	4.7	1.25	.50	7.7	5°	70	3.4	1.2	760	.07	7.3	20.5	18		38500	
1300	58			39000	4.7	1.3	.50	7.7	5°	70	3.6	1.2	700	.09	7.3	18	15.2		33200	
1400	61			40000	4.7	1.0	.50	7.7	5°	72	2.0	1.2	770	.10	7.3	18	15		33000	
1500	61			40000	4.6	1.25	.52	7.7	5°	72	2.9	1.2	735	.09	7.3	18	15		33000	
1600	61			40000	4.6	1.3	.82	7.7	5°	72	3.6	1.2	710	.08	7.3	18	15		33000	
1700	61			40000	4.6	1.3	.54	7.7	5°	60	3.7	1.2	770	.08	7.3	21	18		39000	
1800	61			40000	4.6	1.3	.54	7.7	5°	60	3.8	1.2	770	.08	7.3	21	18		39000	
1900	61			40000	4.6	1.3	.54	7.7	5°	60	4.0	1.2	770	.10	7.3	21	18		39000	
2000	61			40000	4.6	1.3	.54	7.7	5°	60	4.2	1.2	770	.10	7.3	21	18		39000	
2100	61			40000	4.4	1.3	.54	7.7	5°	60	4.5	1.2	770	.10	7.3	21	18		39000	
2200	61			40000	4.6	1.3	.54	7.7	5°	60	4.8	1.2	770	.12	7.3	21	18		39000	
2300	64			40000	4.6	1.3	.54	7.7	5°	60	2.9	1.2	730	.13	7.3	18	14.3		32500	
2400	64			40,000	4.6	1.3	.56	7.7	5	60	3.6	1.2	730	.09	7.3	18.3	14.2		32,500	

	Raw Water Ml/d
2400	74521160
PRE	74481810
M3/d	39,350
MAX.	40,000
MIN.	38,000

	Hydro kwh .53
2400	7680.2
PRE	7673.9
TOTAL	6.3 18900
PEAK	1010 kw 07:00

High Lift Flow Readings .08

	1	2	3
2400	36691060	33570910	
PRE	36670940	33553300	
TOTAL	20120	17610	37730
MAX.			39,000
MIN.			32,500

HIGH LIFT PUMP HOURS

	1	2	3	4	5	6
		ON	OFF			
		OFF	ON			
2400		4481.5	3096.7	74?	?	?
PRE.		4478.0	3577.1	8350.8	10230	1020.1
TOTAL		4.5	19.6	24	0	0

LOW LIFT PUMP HOURS

	1	2	3	4
2400	3706.0	6254.0	4210	
PRE.	3682.0	6254.0	4210	
TOTAL	24	0	0	

INSPECTIONS

	23.30	07.30	15.30
WEATHER	CLEAR	CLEAR	CLEAR
WIND	W	N	N
O. TEMP.	-33°	-40°	-23°
LAKE	ICE	ICE	ICE
TRANS. 1	49	48°	48°
2	50	49°	50
3	50	50°	50
4	5	5	5
5	5	5	5
P.S.M. 1	2330	2330	2330
P.S.M. 2	590	590	590
P.S.M. 3	2380	2380	2380

REMARKS: T.C.

00.00	08.00	16.00
F	RR	RI

SHIFT OPERATORS INITIAL

182124

571,200 KW ÷ 31 = 18425.81

BARE POINT WATER TREATMENT PLANT

MONTHLY REPORT

MONTH JANUARY YEAR 1983

RAW WATER:	TOTAL FOR MONTH	AVERAGE PER DAY
MAXIMUM RATE - (Mld)	1140.00	36.77
MINIMUM RATE - (Mld)	913.00	29.45
TOTAL RATE - (Mld)	1052.66	33.96
MAXIMUM DAY - (Ml)	Jan. 29	36.60
MAXIMUM RATE - (Ml)	Jan. 18	46.00

TREATED WATER:	TOTAL FOR MONTH	AVERAGE PER DAY
MAXIMUM RATE - (Mld)	1018.10	32.84
MINIMUM RATE - Mld)	740.02	23.87
TOTAL RATE - (Mld)	902.72	29.12
MAXIMUM DATE - (Ml)	Jan. 27	32.12
MAXIMUM RATE - (Mld)	Jan. 6	45.30

RAW WATER:		TOTAL FOR MONTH	AVERAGE PER DAY
TEMPERATURE - (C)	31	130.00°	4.19°
P.H.	20	146.71	7.34
HARDNESS - ($CaCo_3$)mg/l	9	408.60	45.80
ALKALINITY - ($CaCo_3$)mg/l	7	318.60	45.50
IRON - (Fe)	2	.10	.05
CHLORIDE (Cl) mg/l	2	4.1	2.5
COLOUR (HAZEN UNITS)	1	9	9
TURBIDITY (FORMAZIN UNITS)	27	16.58	0.61
CONDUCTIVITY (umHos/cm)	2	212.0	106.0
ALUMINUM - mg/l	2	0.002	0.001
BACTERIOLOGICAL (T.C.)			< 2
ODOUR		OK	OK

TREATED WATER:		TOTAL FOR MONTH	AVERAGE PER DAY
TEMPERATURE - (C)	31	130.00°	4.19°
P.H.	21	146.45	6.97
HARDNESS ($CaCo_3$)mg/l	9	392.60	43.62
ALKALINITY - ($CaCo_3$)mg/l	9	381.60	42.40
IRON - (Fe)	2		<.05
CHLORIDE (Cl) mg/l	2	7.4	3.7
COLOUR (HAZEN UNITS)	1	< 5	<5
TURBIDITY (FORMAZIN UNITS)	27	3.95	0.15
CONDUCTIVITY (umHos/cm)	2	221.0	110.5
ALUMINUM - mg/l	2	0.010	0.005
BACTERIOLOGICAL (T.C.)			AB
ODOUR		OK	OK
TASTE		OK	OK

CHEMICALS:		
ALUM USED (kg)	9079.20	292.88
ALUM DOSAGE (mg/l)	266.66	8.60
POLYMER USED NON-IONIC (kg)	203.48	6.56
POLYMER DOSAGE (mg/l)	5.93	0.19
POLYMER USED CATIONIC (kg)		
POLYMER DOSAGE (mg/l)		
SODIUM CHLORITE USED (kg)		
DOSAGE (mg/l)		

DISINFECTION:		
CHLORINE USED - (kg)	1831.26	59.0
DOSAGE - (mg/l)	53.83	1.7
RESIDUAL - (mg/l)	41.21	1.3

PLANT EFFICIENCY:		
TURBIDITY - % REMOVAL	1205.64%	75.3
ASBESTOS - % REMOVAL		
BACTERIA - % REMOVAL		

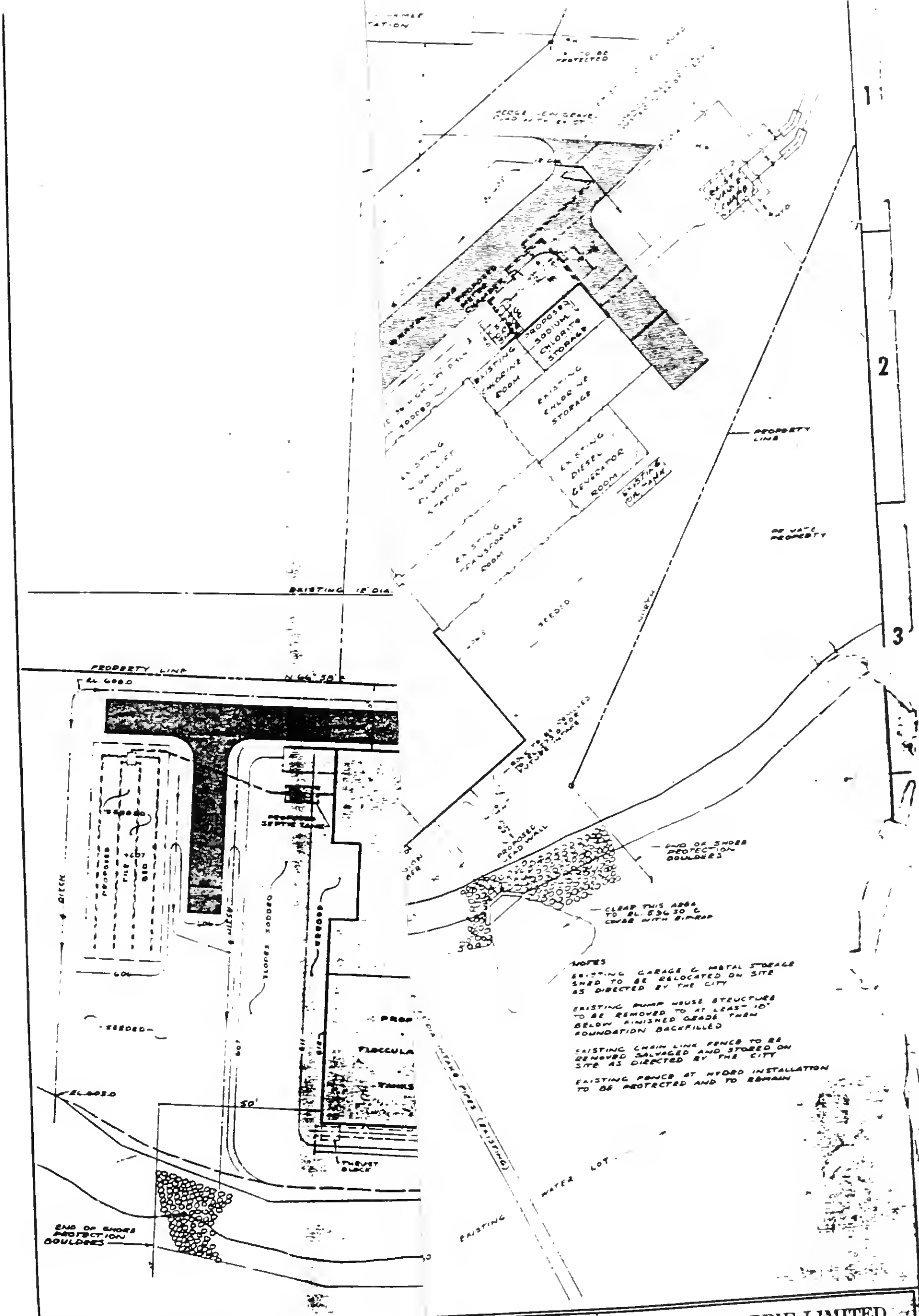
FLOCULATION:		
FLOC TANKS IN SERVICE	124.00	4.00

POWER CONSUMPTION:		
BARE POINT (KWH)	516,200	16,684
CHAMBERLAIN (KWH)	57,672.0	1,860
MCINTYRE (KWH)	23,580.0	7'
HODDER AVENUE (KWH)	7,965.0	
DUKE STREET (KWH)	8,544.0	

FILTERS:		
FILTERS IN USE	93.00	3.00
FILTER BACKWASHED	91.00	2.94
BACKWASH WATER USED (Mld)	143.57	4.63

[signature]

APPENDIX C - DRAWING



NOTES

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DER BAY

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ION PLANT

GORE & STORRIE LIMITED
CONSULTING ENGINEERS
TORONTO ONTARIO

DATE OCTOBER 1976

SCALE 1" = 20'-0"

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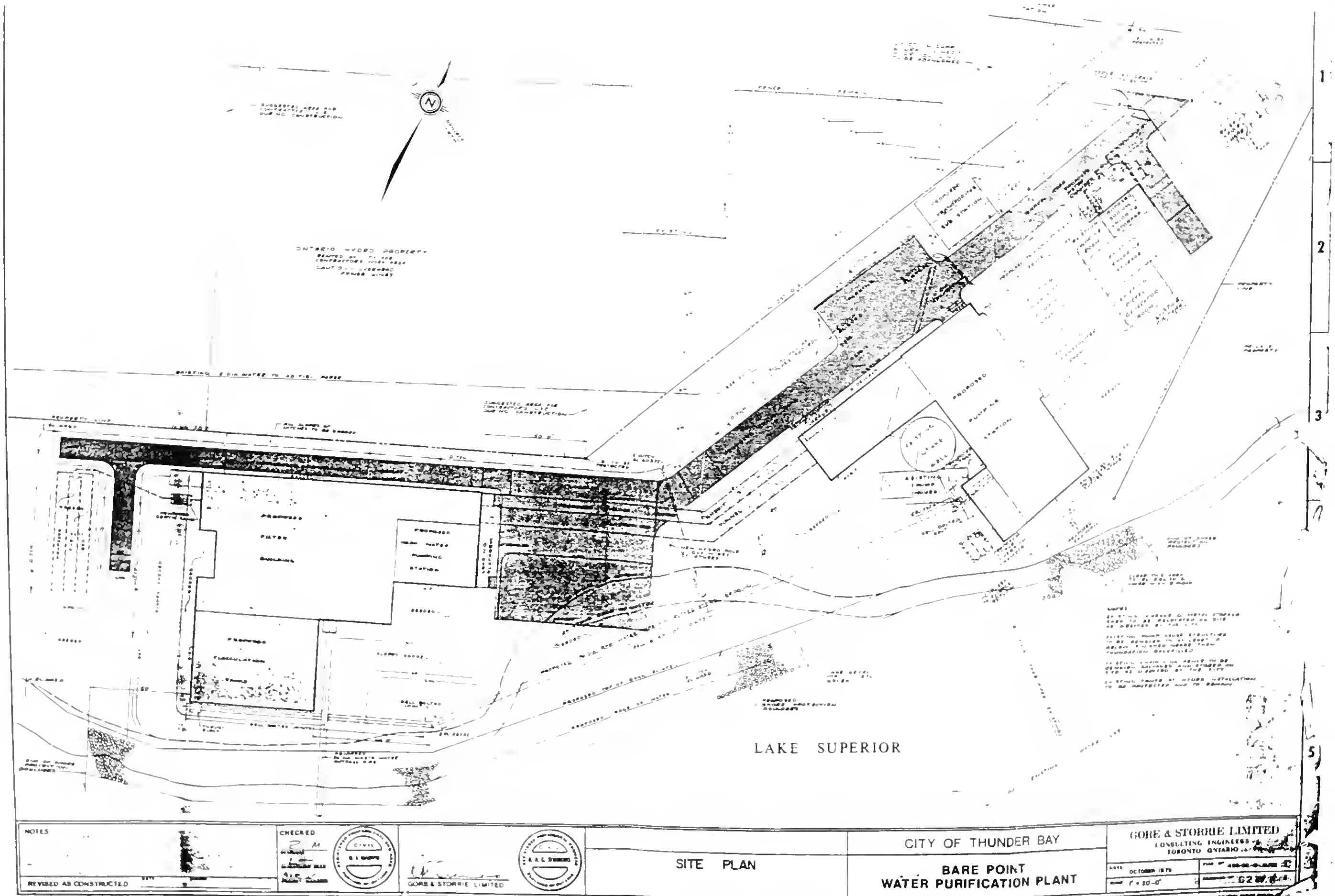

ONTARIO HYDRO PROPERTY
PROPOSED
FILTER
BUILDING
PROPOSED
PUMPING
STATION
LAKE SUPERIOR
NOTES
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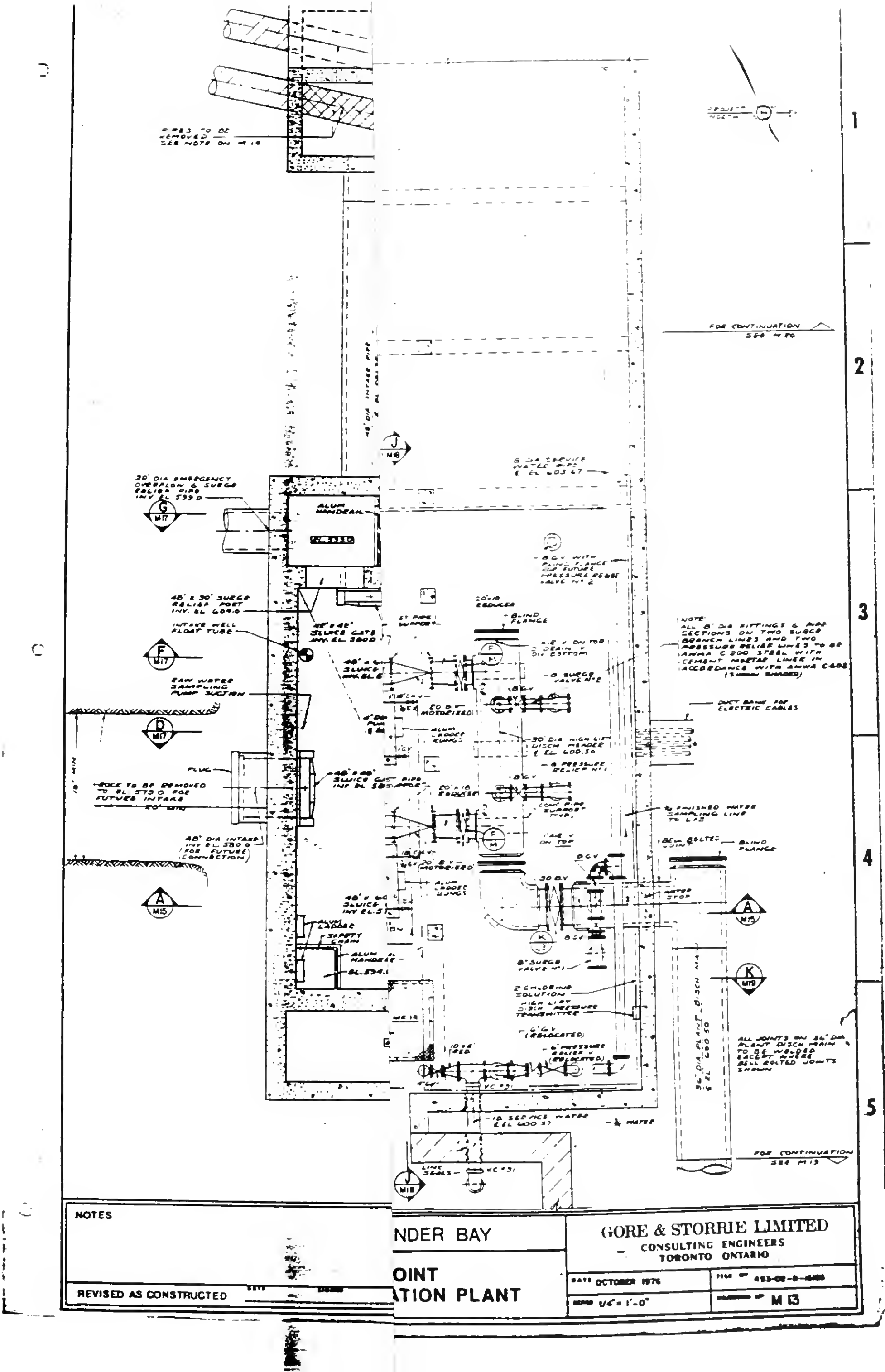
GORE & STORRIE LIMITED
SITE PLAN
CITY OF THUNDER BAY
BARE POINT
WATER PURIFICATION PLANT
GORE & STORRIE LIMITED
CONSULTING ENGINEERS
TORONTO ONTARIO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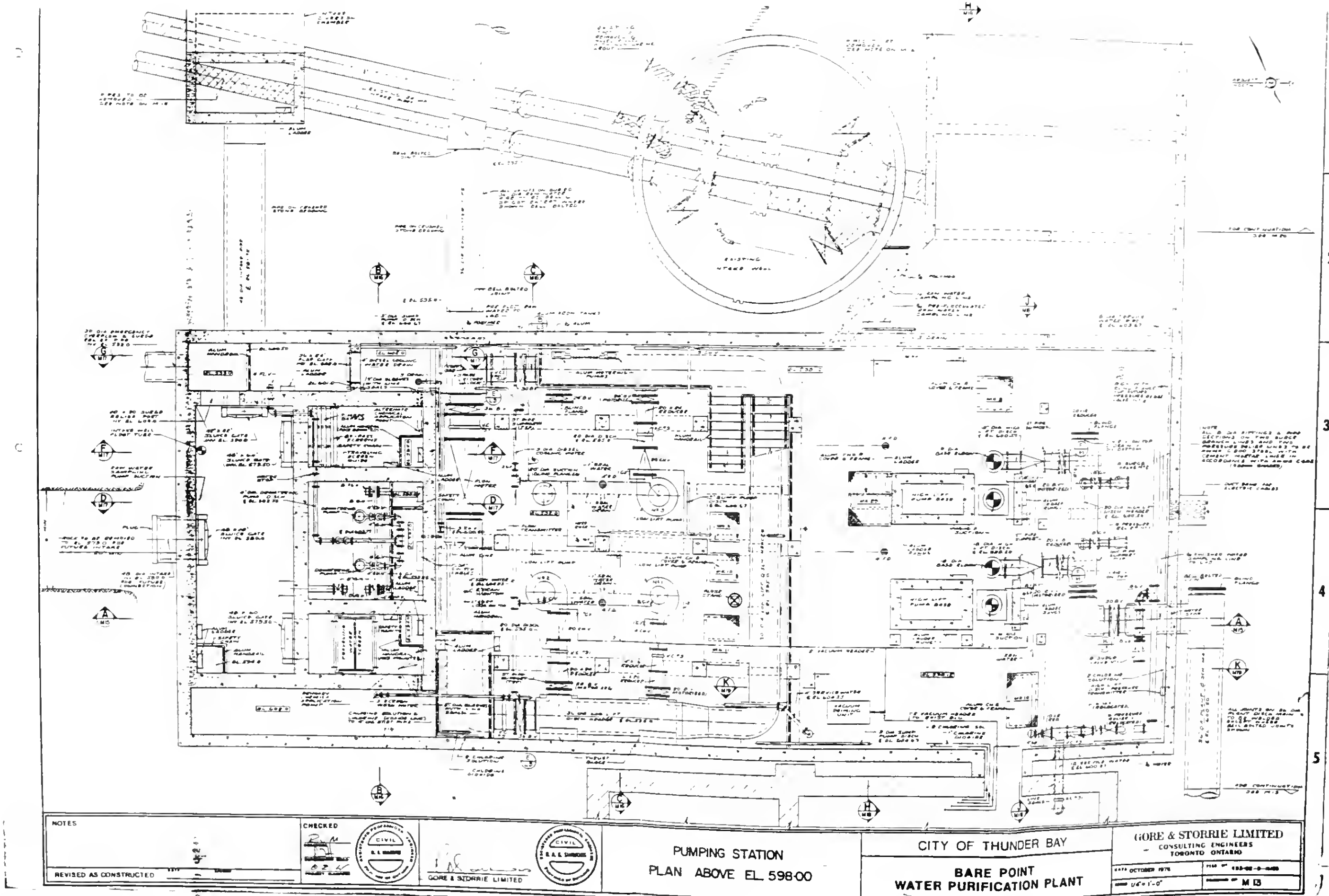
ATION PLANT
GORE & STORRIE LIMITED
CONSULTING ENGINEERS
TORONTO ONTARIO
DATE OCTOBER 1976
SCALE 1/4" = 1'-0"
M 13
FOR CONTINUATION SEE M 20
FOR CONTINUATION SEE M 19
PLUG
ALUM LADDER
SAFETY CHAIN
DUCT BANK FOR ELECTRIC CABLES
BLIND FLANGE
1
2
3
4
5



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GORE & STORRIE LIMITED
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PLAN ABOVE EL. 598·00
CITY OF THUNDER BAY
BARE POINT
WATER PURIFICATION PLANT
GORE & STORRIE LIMITED
CONSULTING ENGINEERS
TORONTO ONTARIO
OCTOBER 1976
1/4" = 1'-0"
M 13
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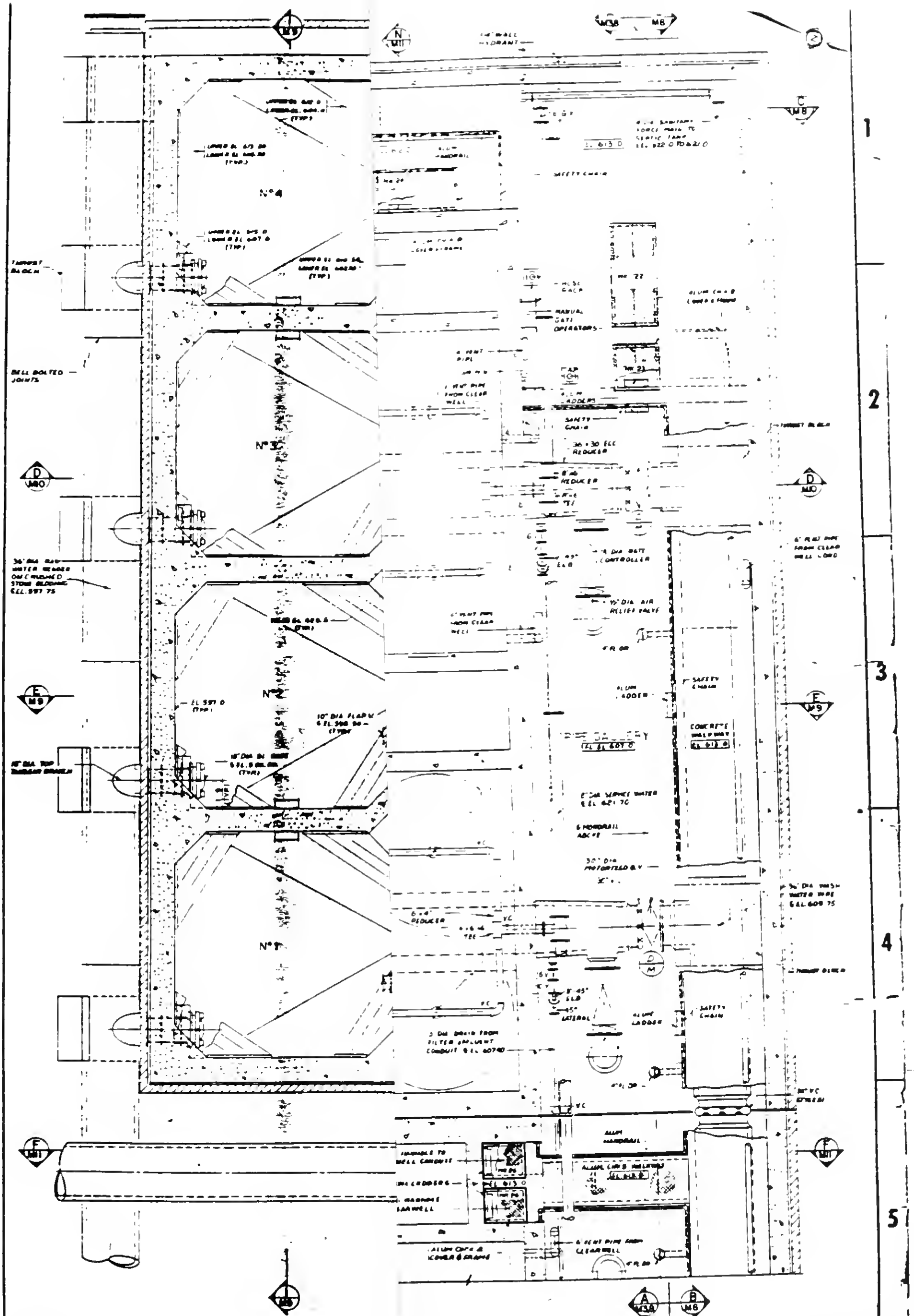

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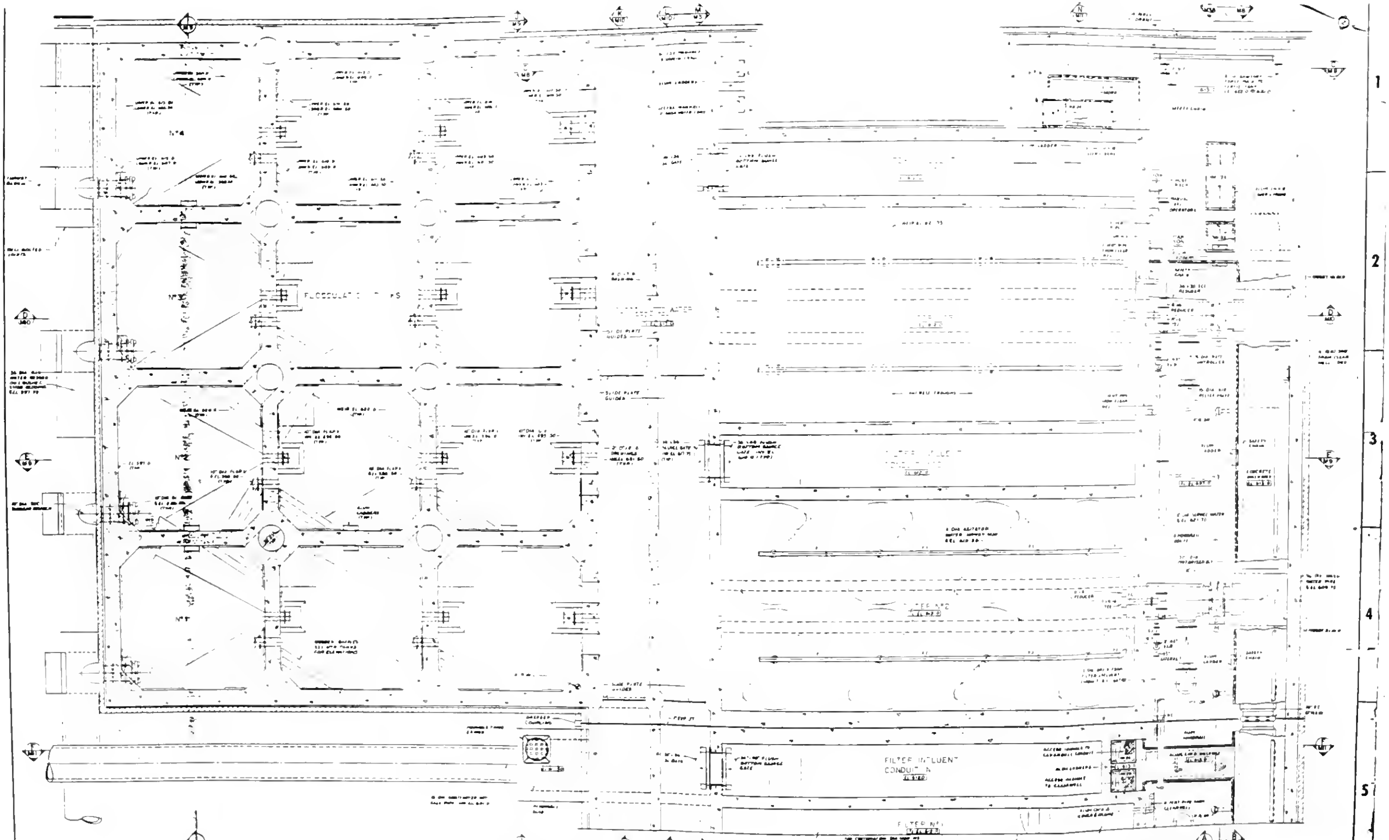
GORE & STORRIE LIMITED
CONSULTING ENGINEERS
TORONTO ONTARIO

DATE OCTOBER 1976

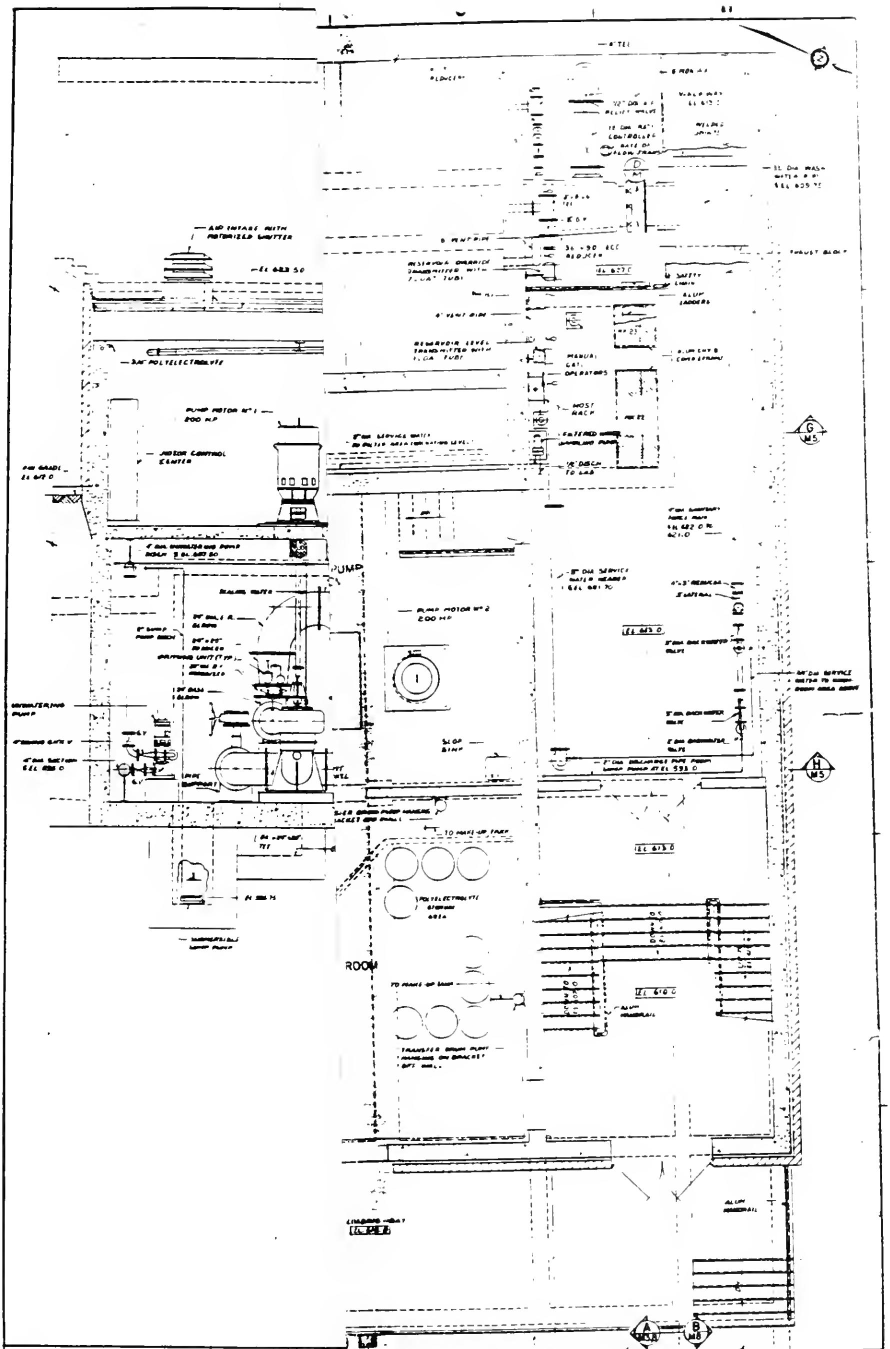
SCALE 1/4" = 1'-0"

DRAWING No M 4



PLAN ABOVE EL. 613·00

NOTES	CHECKED	FILTERS AND FLOCCULATION TANKS PIPE GALLERY LEVEL PLAN	CITY OF THUNDER BAY	GORE & STORRIE LIMITED CONSULTING ENGINEERS TORONTO ONTARIO
REVISED AS CONSTRUCTED	GORE & STORRIE LIMITED		BARE POINT WATER PURIFICATION PLANT	DATE OCTOBER 1976 · SCALE 1/8" = 1'-0" · DRAWING Nº M 4



NOTES

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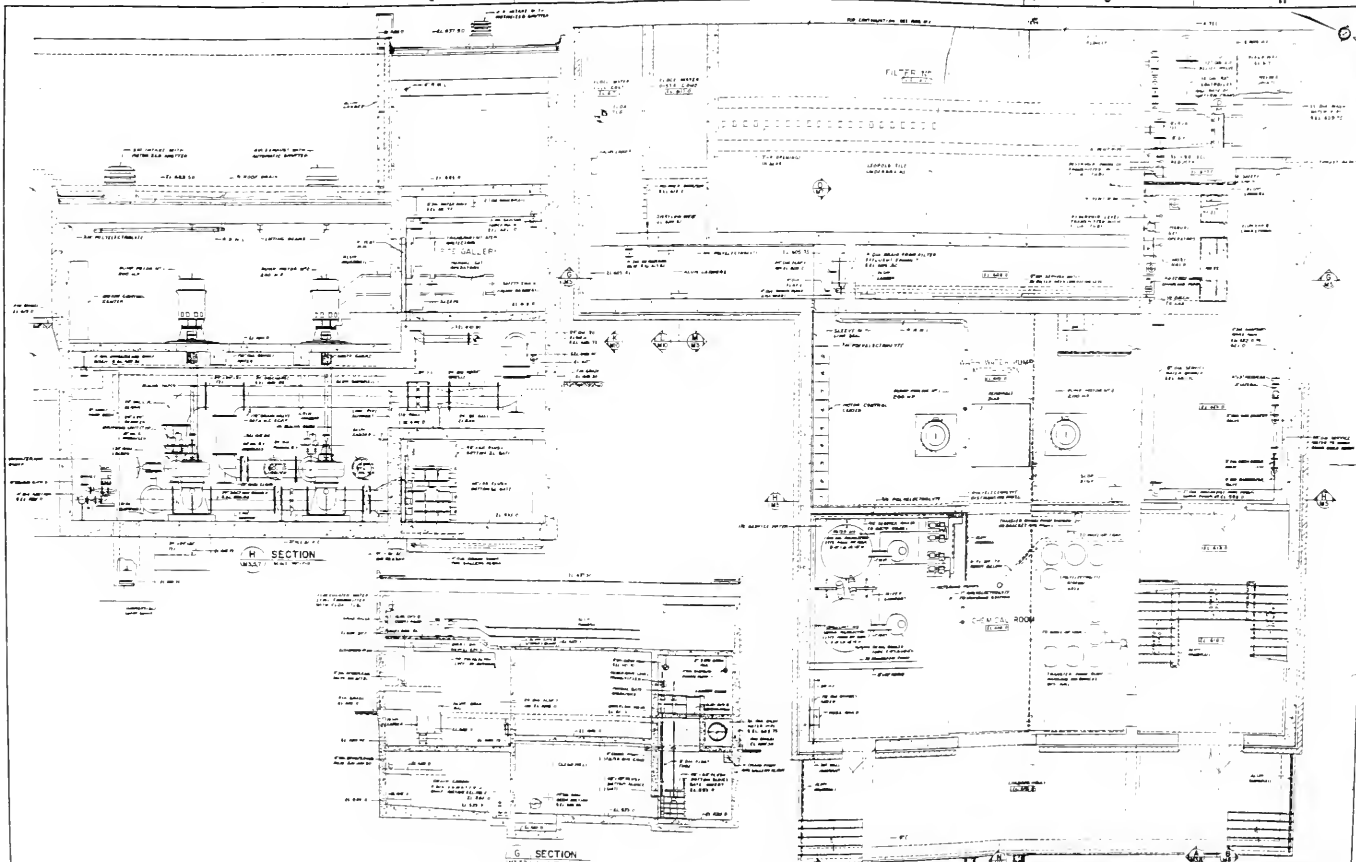
HUNDER BAY

POINT
CATION PLANT

GORE & STORRIE LIMITED
CONSULTING ENGINEERS
TORONTO ONTARIO

DATE	OCTOBER 1976	FILE No	493 02-D-96158
SCALE	1/4" = 1'– 0"	DRAWING No	M 5



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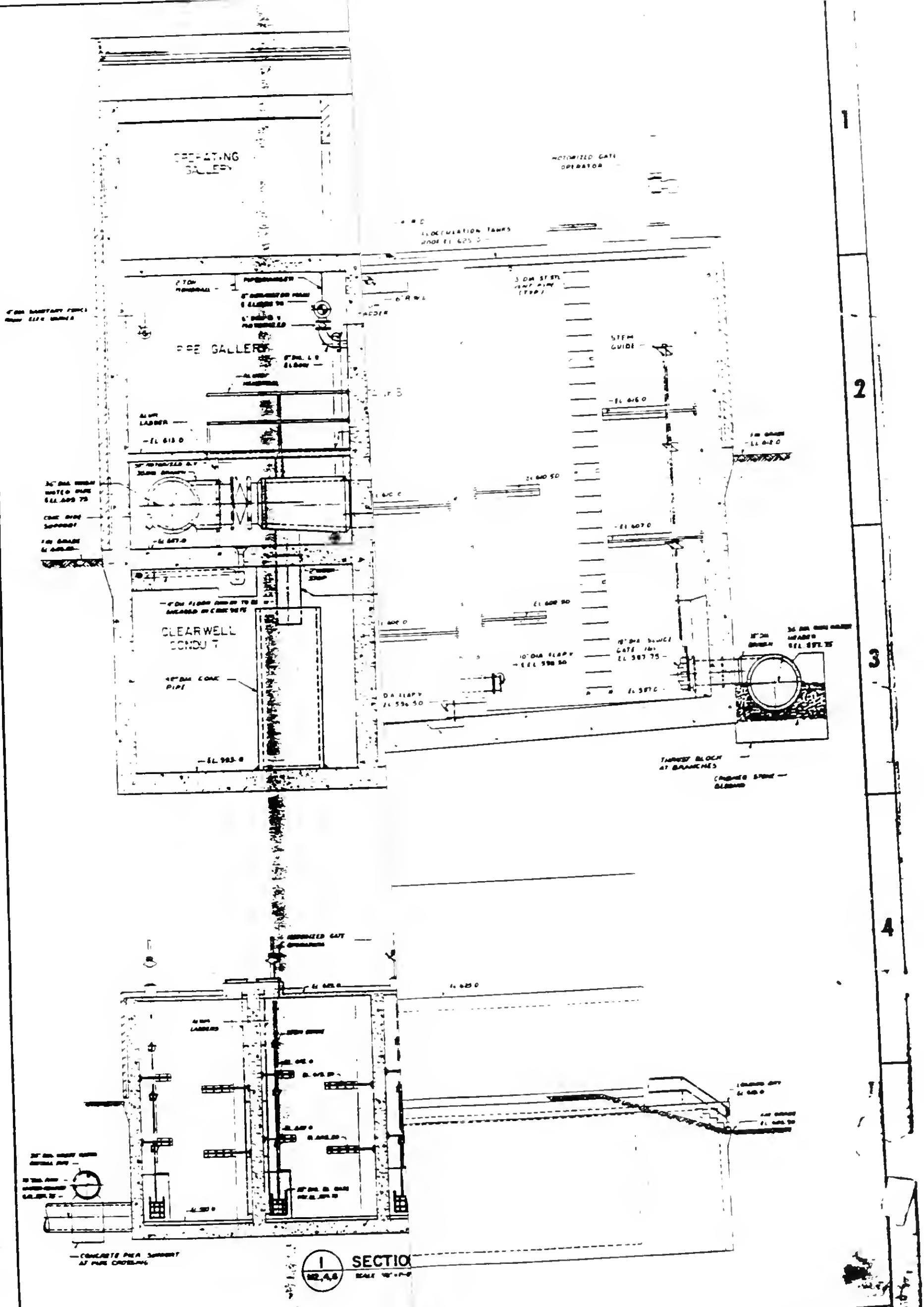
REVISED AS CONSTRUCTED		GORE & STORRIE LIMITED				DATE OCTOBER 1975 · SCALE 1/4" = 1'-0" · DRAWING No. M 5



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TORONTO ONTARIO

DATE OCTOBER 1976	FILE NO 493-[illegible]
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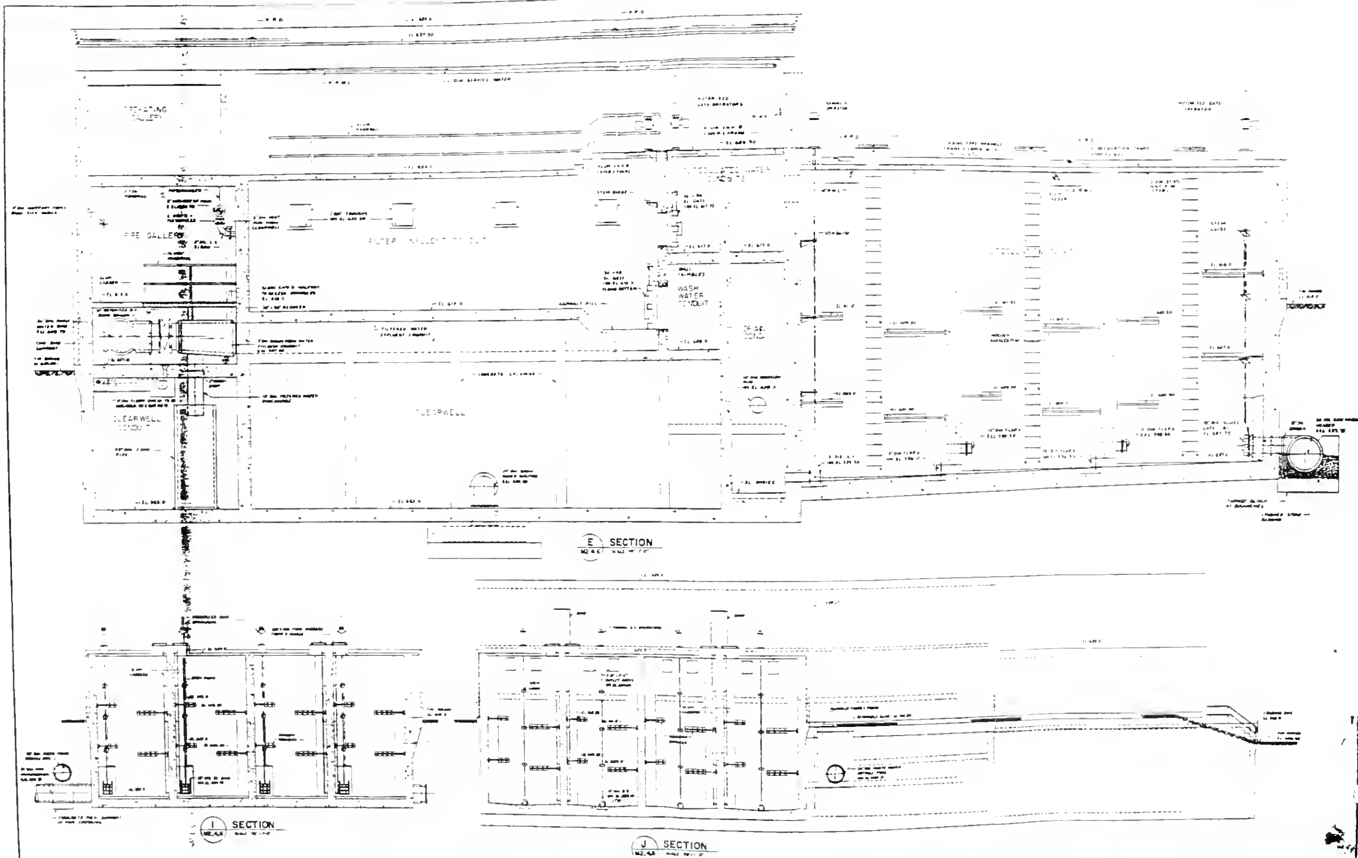

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GORE & STORRIE LIMITED

FILTER PLANT
SECTIONS (1)

CITY OF THUNDER BAY

BARE POINT
WATER PURIFICATION PLANT

GORE & STORRIE LIMITED
CONSULTING ENGINEERS
TORONTO ONTARIO

OCTOBER 197[illegible]

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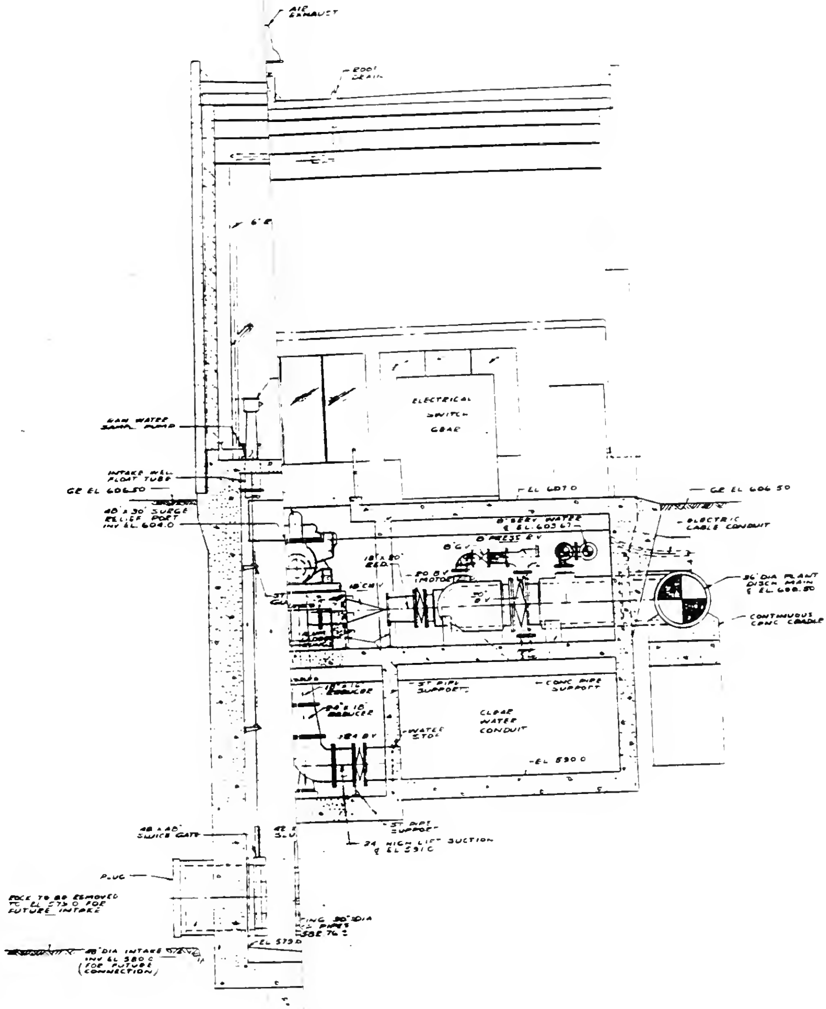
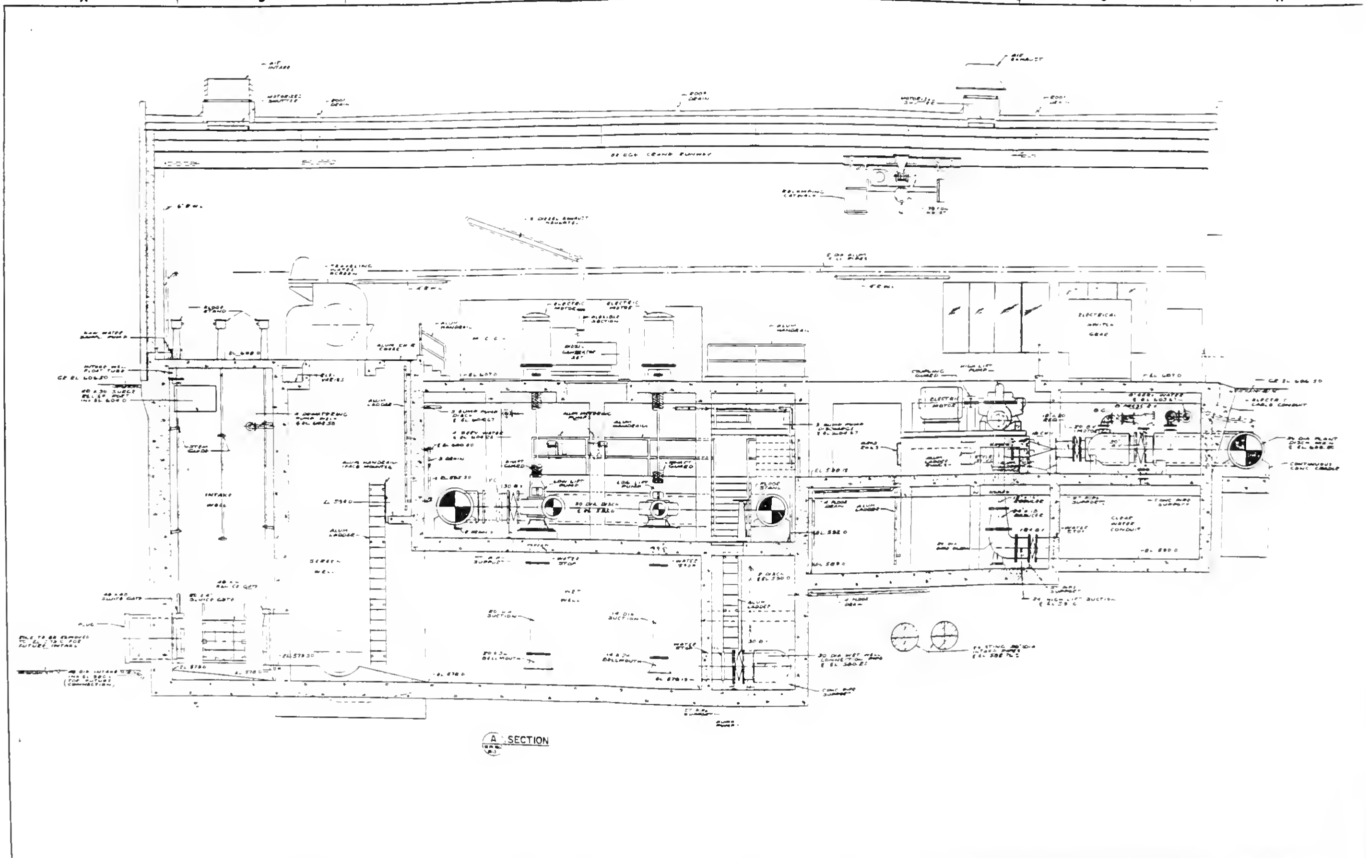


NOTES	THUNDER BAY	GORE & STORRIE LIMITED CONSULTING ENGINEERS TORONTO ONTARIO
REVISED AS CONSTRUCTED	...E POINT ...FICATION PLANT	DATE OCTOBER 1976 · FILE Nº 493-02-D-18168 SCALE 1/4"=1'-0" · DRAWING Nº M15



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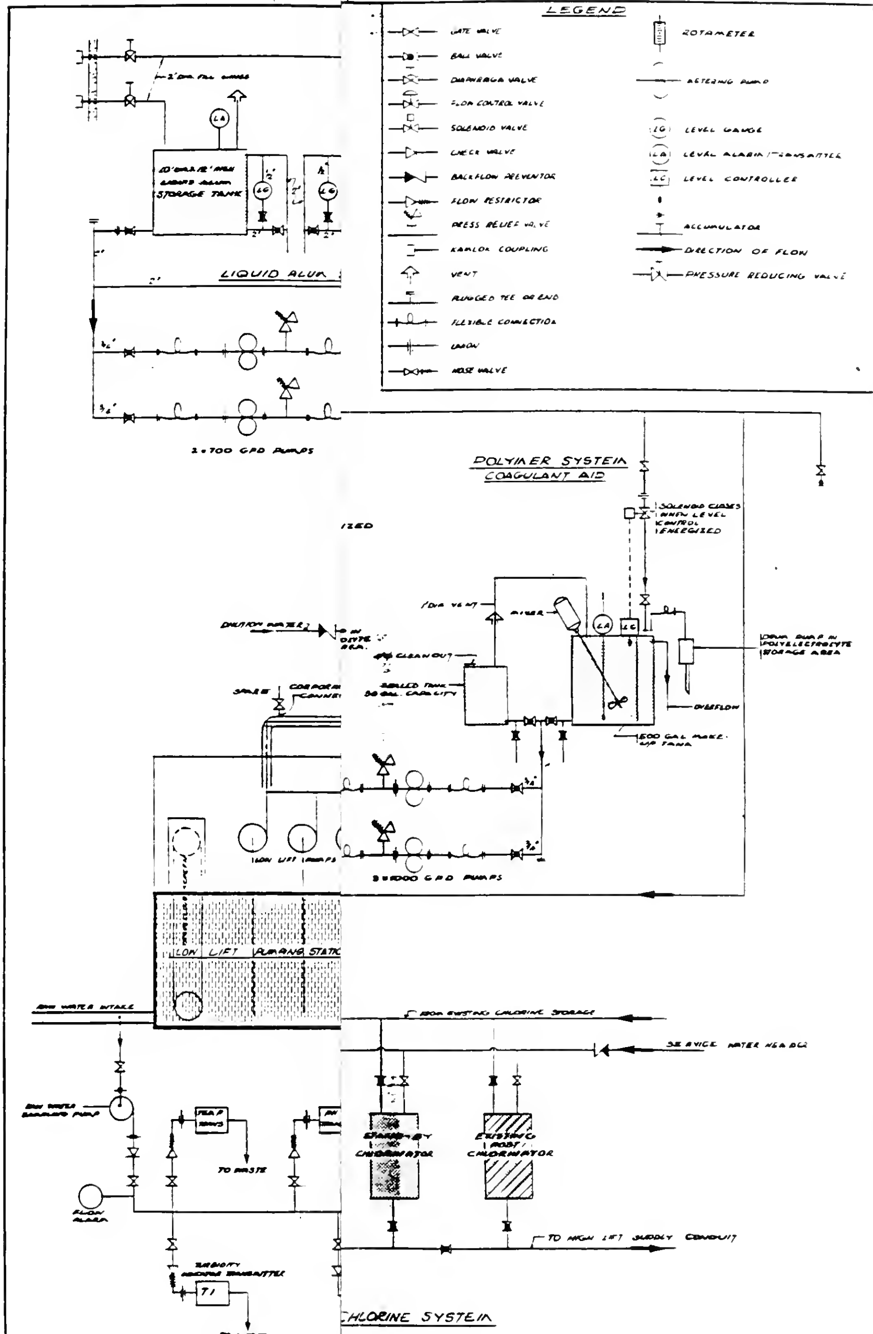

NOTES

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HUNDER BAY

POINT
CATION PLANT

GORE & STORRIE LIMITED
CONSULTING ENGINEERS
TORONTO ONTARIO

DATE	OCTOBER 1976	FILE No	493 02-D-16176
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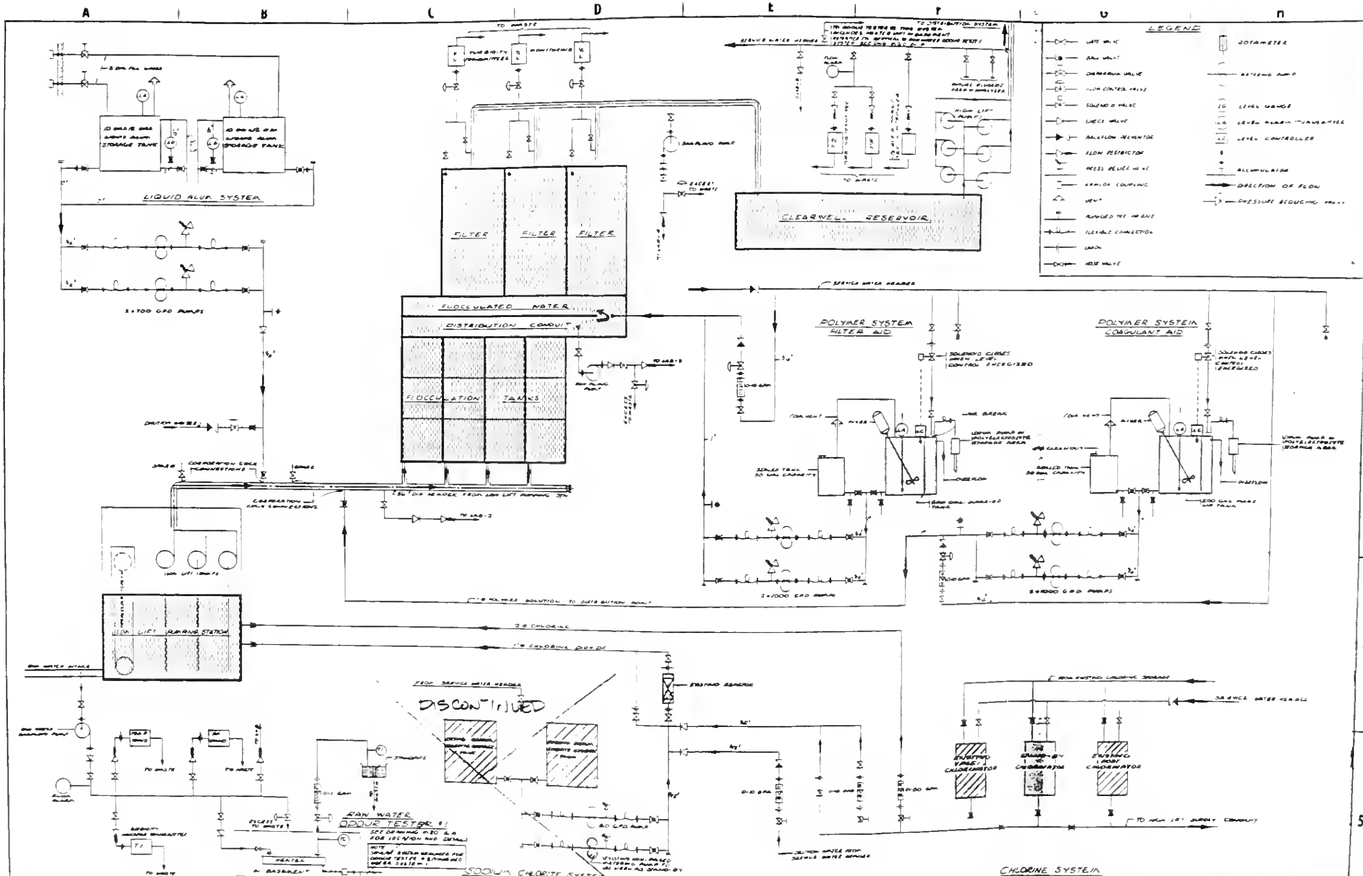


NOTES	CHECKED		CHEMICAL FEED SCHEMATICS	CITY OF THUNDER BAY BARE POINT WATER PURIFICATION PLANT	GORE & STORRIE LIMITED CONSULTING ENGINEERS TORONTO ONTARIO
REVISED AS CONSTRUCTED		GORE & STORRIE LIMITED			DATE OCTOBER 1976 SCALE NOT TO SCALE DRAWING No. M 23

LOCH LOMOND WATER TREATMENT PLANT

PART 2

LOCH LOMOND WATER TREATMENT PLANT

WATER PLANT OPTIMIZATION STUDY
THUNDER BAY, LOCH LOMOND WATER TREATMENT PLANT

SUMMARY OF FINDINGS AND RECOMMENDATIONS

As noted in the Summary to Part 1 of this report, the intent of this study is to provide a review of present conditions at the Loch Lomond Water Treatment Plant, with an emphasis on determining an optimum treatment strategy for removal of particulate matter and improving the disinfection process.

The Loch Lomond plant provides disinfection and aggression control only, and does not include filtration. While the plant is well operated and maintained, it does not have the ability to remove particulates.

The following items have been identified for upgrading and improvement:

- Undertake additional source protection measures, including consideration of both quality and quantity of the supply

- Undertake studies of alternative disinfectants to reduce trihalomethane (THM) levels

- Improve the operation of the flow control valves, in order to more accurately respond to changes in reservoir level, and to provide more accurate chlorine dosage

- In order to provide particulate and colour removal, provide a water treatment plant incorporating coagulation and filtration, in accordance with pilot plant studies conducted in 1985. Alternatively, consider exclusive use of the Bare Point plant for supply to the areas of the City currently served by Loch Lomond.

INTRODUCTION

Loch Lomond is located on Indian Reserve No. 52 and it is the water supply source for the southern part of Thunder Bay (formerly known as Fort William). The supply is situated at an approximate elevation of 285.860 m, which is some 100 meters above Lake Superior. Since the supply is above the City of Thunder Bay, it is operated entirely by gravity.

The lake has the following characteristics.

Minimum Lake Level	284.56 m (1977)
Surface Area	16.12 sq.km
Drainage Area	61.59 sq.km
Minimum Annual Recharge Potential	14,530 ML
Normal Annual Recharge Potential	19,750 ML
Average Annual Demand	15,830 ML

The natural outlet of the lake is along the Carp River to Lake Superior. A control dam exists on the Carp River and this controls the level of water in Loch Lomond by releasing the high water levels in spring. After the release of spring run-off, the dam is usually closed for the remainder of the year with the lake level dependent upon water demand, precipitation, run-off, evaporation and evapotranspiration. The low water level generally occurs in winter prior to the first thaw.

There is some source protection carried out for this supply. Loch Lomond is situated on Indian Reserve No. 52 with a land lease that expires in 1998.

SECTION A - RAW WATER SOURCE

SECTION A - RAW WATER SOURCE

A.1 Source

The Loch Lomond Water Treatment Plant takes raw water from the south end of Loch Lomond. The raw water enters a 900 mm diameter cast iron intake, 228 metres long which discharges to a gatehouse at the shoreline. The raw water then flows through a 1,544 metre long tunnel to a concrete forebay containing removable screens.

A.2 Physical Parameters

The raw water characteristics are shown in the following Table 1 and are compared with the treated water in Table 2. Over the three year study period, it has been observed that the turbidity ranges from 0.24 to 7.25 FTU. The turbidity levels are normally between 0.35 and 0.52 FTU. The raw water colour ranges from 16.3 to 28.5 TCU, with an average of 13 TCU, well above the Ministry of the Environment guideline of 5 TCU.

A.3 General Chemistry

The raw water from Loch Lomond has characteristics similar to many Northern Ontario Lakes. These are a pH range from 7 to 7.5, a low alkalinity (16-25 mg/L) and a low hardness level (18-31 mg/L). Waters such as this are considered to be aggressive and can cause substantial corrosion of any metal parts with which the water comes in contact over a period of time. The increased aggressiveness of a source is due to one or more of the following conditions:

(a) Lower pH of water-
more acidic and therefore more likely to leach metals from pipes.

(b) Lower hardness -
less calcium and magnesium deposition to protect pipes.

(c) Lower alkalinity -
less carbonate/bicarbonate present to neutralize acidic water.

An indication of the degree of corrosivity is given by the Langelier Index, the calculation of which includes pH, water temperature, total dissolved solids, hardness and alkalinity.

The Index for the Loch Lomond raw water is below zero, which is indicative of a very aggressive water, and ranges from approximately -1.75 to -2.85 for the range of basic parameters.

The alkalinity of the Loch Lomond water is fairly low, which gives the water very little buffering capacity and could make it susceptible to the effects of acid rain. The alkalinity and pH of Loch Lomond water have not, however, changed in the past decade and acid rain is not therefore thought to be adding to the problem.

TABLE 1

Loch Lomond - Raw Water

Chemical Parameter	Value	MOE Objective
pH	7.1	6.5-8.5
Hardness ($CaCO_3$)(mg/L)	24.7	80-100
Alkalinity ($CaCO_3$)(mg/L)	19	30 - 500
Dissolved Organic Carbon (mg/L)	13	<5
Colour (TCU or HU)*	13	<5 TCU**
Turbidity (FTU)*	0.43	<1.0 NTU**
Conductivity (umhos/cm)	62.9	
Magnesium (mg/L)	2.3	
Nitrogen Total Kjeldahl (mg/L)	0.26	
Nitrate (mg/L)	0.15	10
Total Phosphorous (mg/L)	0.09	
Aluminum mg/L	0.032	0.1
Iron mg/L	0.025	0.3

* Plant Record Units

** Guideline Units

The data in this Table has been obtained from a combination of data from Thunder Bay Annual Reports and the draft Distribution System Survey undertaken in 1986/87 by Proctor & Redfern Limited for the Ministry of the Environment.

TABLE 2

Loch Lomond Raw and Treated Water

Chemical Parameter Objectives	Raw Water Range	Treated Water Range	MOE Objectives
Turbidity (FTU)*	0.24-7.25	0.250-2.30	<1.0NTU**
pH	6.98-7.45	7.43-9.90	6.5-8.5
Hardness ($CaCO_3$)(mg/L)	18.43-31.20	20.49-57.26	80-100
Alkalinity ($CaCO_3$)(mg/L)	16.5-25.06	18.50-50.71	30 - 500
Colour (TCU*)	16.3-28.5	5.0-17.0	<5TCU**
Conductivity (umhos/cm)	54.5-62.33	62.0-127.0	
Iron (mg/L)	0.05-0.80	<0.05-0.15	<0.3

* Plant Record Units

** Guideline Units

The date in this Table has been derived from the same sources used for Table 1.

It can be seen from Table 1 that both the dissolved organic carbon and colour values are elevated at 13 mg/L and 13 TCU respectively. In view of the treatment, or lack thereof, carried out at this plant there may be problems with triahalomethane production. This is discussed at further length in Section F.3. It would appear that organic nitrogen is present in the raw water. Although this level of organic nitrogen is very low at 0.14 mg/L, and represents no health hazard, it may give taste problems when combined with chlorine. The other parameters examined in Table 1 are typical for a Northern Ontario Lake.

On the whole, metal levels were below detectable limits. Cadmium and chromium were detected, but at levels well below the maximum acceptable

concentrations, of 0.005 mg/L and 0.05 mg/L respectively. Iron and aluminum were present at low concentrations (0.025 mg/L and 0.032 mg/L, respectively) and are of no health nor aesthetic concern.

A.4 Bacteriological

The raw water from Loch Lomond contains fecal coliforms and fecal streptococci at very low levels in the range of less than 2.2 to 3.0. The levels of total coliform were elevated between June and September. During this period, levels as high as 403 per 100ml for total coliform were recorded. The raw water also contained active protozoa (17 per litre), algae and mastigophora at 5,414 and 2,627 per litre respectively. These figures are obtained from the Ministry of the Environment Distribution System survey of Thunder Bay, 1986-1987.

In all cases the disinfection process successfully eliminated these forms of bacteriological contamination. These results are tabulated and compared in Table 4 Section F.

A.5 Source Protection

Source protection is an important issue in maintaining the quality of any water supply. This is particularly true in the case of supplies such as Loch Lomond where limited dilution is available to reduce the effects of contamination. Some source protection measures have been taken at Loch Lomond.

Principally, the Indian Band have agreed not to undertake logging in the area surrounding Loch Lomond. As a result, particulates, phenols and other characteristics associated with logging should be lower than previously found in Loch Lomond water.

Another method of protection is to eliminate the beaver colonies around the source and thus limit the introduction of fecal coliforms and Giardia cysts to the water.

SECTION B - FLOW MEASUREMENT

SECTION B - FLOW MEASUREMENT

B.1 Discharge Flow

The water from Loch Lomond is metered as it enters the reservoir at the treatment plant. Three pipelines enter the reservoir, two of 600 mm diameter and one of 450 mm diameter. The flow is measured by three Bailey orifice plates (one on each pipeline). They have the following characteristics:

pressure differential	-	0-3.048 metres W.C. (0-120 inches)
maximum rated flow:		
600 mm dia.	-	44.0 ML/d (9.68 MIGD)
450 mm dia.	-	22.7 ML/d (5.0 MIGD)

The flow is locally indicated in the chlorination building next to the valve chamber where the orifice plates are located. It is also totalized continuously and recorded and totalled every day on the daily record. The raw water flow varied from 15.0 to 60.2 ML/d during the study period, with an average of 37.7 ML/d. With the above ranges, each 600 mm orifice plate is subject to a range of 7.5:1 to 1.9:1. (This takes into account the constant flow in the 450 mm pipe and the modulated flow in the two 600 mm pipes).

B.2 Validity

There are no reported problems with the accuracy of the metering at the Loch Lomond Plant. The transmitters are checked and zeroed each month and calibrated with a manometer yearly by a qualified instrument technician on staff. The flow data in Table 1.0 of the Appendix shows data with no anomalies nor apparent difficulties. Maximum and minimum discharge flow dates throughout the study period are as follows:

Maximum & Minimum Flow Periods

	1983	1984	1985	1986
Maximum	July	Sept.	Dec.	Aug.
Minimum	April	Sept.	Oct.	Sept.

The per capita flow tabulated below shows the minimum, average and maximum day requirements for the portions of the City serviced by the Loch Lomond Plant. Also in the same Table are the minimum, average and maximum day flows per capita for the area of the City serviced by the Bare Point Supply.

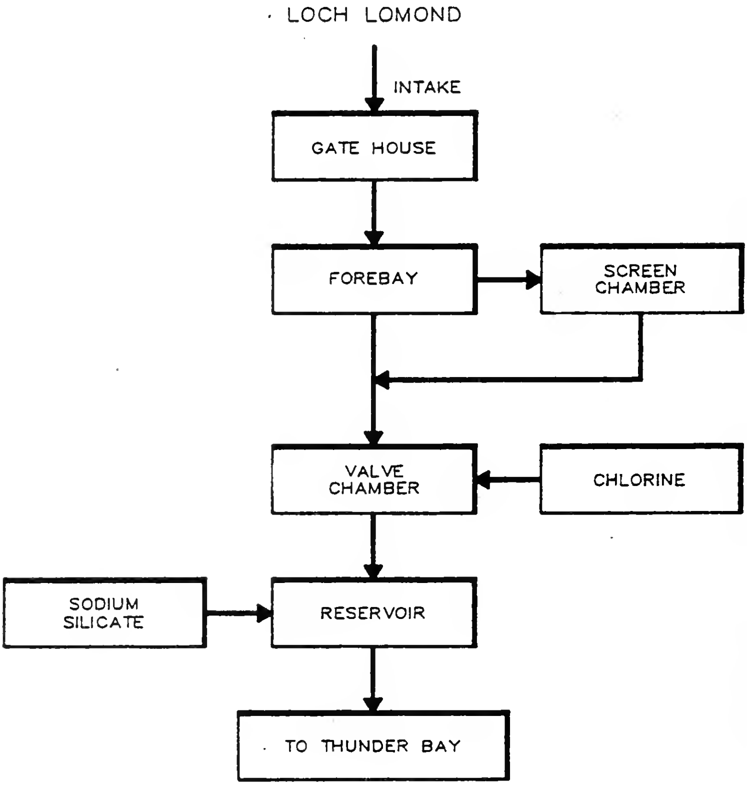
Per Capita Consumption (L/day/capita)

Population	1983	1984	1985	1986
Bare Point Area	55,006	54,560	55,526	56,116
Loch Lomond Area	50,876	52,083	51,063	50,050
Total	105,882	106,643	106,589	106,166
Maximum				
Bare Point	846	798	882	876
Loch Lomond	1,142	981	1,179	1,074
Minimum				
Bare Point	510	496	409	479
Loch Lomond	440	480	304	731
Average				
Bare Point	593	630	652	672
Loch Lomond	724	687	686	859
Max/Average				
Bare Point	1.43	1.27	1.35	1.3
Loch Lomond	1.58	1.43	1.72	1.25

SECTION C - PROCESS COMPONENTS

LOCH LOMOND WATER TREATMENT PLANT

PROCESS AND PIPING SCHEMATIC



SECTION C - PROCESS COMPONENTS

C.1 General

The Loch Lomond supply system has been in use since 1909 and serves the former Fort William area of Thunder Bay, now known as the South Ward distribution system. The Loch Lomond facility is not a water treatment plant in the traditional sense of the word since it does not contain the coagulation, flocculation, sedimentation and filtration processes. Chemical treatment such as aggression control and disinfection are practiced at the plant.

The following drawings are included in Appendix 1.

(a) Site Plan: Chemical Treatment for Loch Lomond Supply - 493.04 - A1 - 01781, Drawing G1.

(b) Block Schematic

This Section includes detailed information on the unit processes and systems at the Loch Lomond Plant.

C.2 Design Data

(a) **Plant Capacity**

The average daily flow over the three year study period was 37.7 ML/d. The Loch Lomond system operates by gravity. The factors limiting the system capacity are the intake pipe from the Lake to the gatehouse, and the tunnel and pipelines to the treatment reservoir.

The most critical factor is the capacity of the existing intake at low lake levels. The hydraulics of the system are governed by the obvert elevation of the tunnel at the shoreline gate house. At the minimum lake level recorded, the intake system is limited to a theoretical flow of 59.1 ML/d. This is also the approximate theoretical capacity of the existing pipelines from the tunnel outlet forebay to the reservoir which is at an elevation of 274.91 m (902.0 ft).

Under most conditions, however, higher flows can be transmitted. City staff have undertaken testing of these mains, and this indicated flows marginally above the theoretical values.

(b) Intake

A 900 mm diameter cast iron intake extends 228 metres into Loch Lomond at a depth of 10 to 11 metres depending on water level.

The intake discharges to a gatehouse at the shore and then through 1,544 metres of 1.8 m x 1.2 m tunnel beneath a significant height of land to a concrete forebay containing removable screens. The effective area of the tunnel is approximately $2.1m^2$. From the forebay, three pipelines (2 - 600 mm and 1 - 450 mm dia.) discharge to the treatment system/reservoir area. These lines are cast iron and are 3,080 metres long. Velocities in the tunnel section are in the order of 0.28 m/s whereas in the pipelines they range from 0.68 to 0.81 m/s. The tunnel feeder mains were constructed in 1906. Although no recent inspection of the tunnel has been undertaken, there have not been any reported problems associated with the low operating velocities.

(c) Screening

There are several screens throughout the gravity feed system before the water enters the concrete reservoir:

- 4 removable sets of screens in chambers installed at the forebay and screen chamber upstream of the reservoir. (2 screens in the forebay and 2 screens in the chamber.) These screens are approximately 1.5 metres wide and 7.5 metres high and are constructed from fine stainless steel wire cloth. The screen size is unknown.

- One set of screens at the point where the water exits the concrete reservoir. The dimensions and mesh size are unknown.

(d) **Storage**

The Loch Lomond treatment reservoir is divided into 2 cells in series, each measuring 24.4 m x 13.4 m x 6.0 m deep.

The total volume of the reservoir is 3,924 m^3.

C.3 Chemical Systems

(a) **Disinfectant**

Liquid chlorine is stored in a separate area in the chlorine building. The disinfectant is delivered in 900 kg containers and the room is capable of storing 10 such containers.

The Loch Lomond system has three chlorinators located in a building adjacent to the metering and valve chamber.

These chlorinators are all manufactured by Wallace and Tiernan and have the following rotameter ratings:

Unit 1 (600 mm pipeline)	181 Kg/day
Unit 2 (600 mm pipeline)	181 Kg/day
Unit 3 (450 mm pipeline)	90 Kg/day

Chlorine solution is dosed in a chamber upstream of the first cell of the reservoir. Each line extending from the screen chamber, i.e. two - 600 mm and one - 450 mm, is disinfected using a separate chlorinator located in the nearby chlorine building. The flow to the reservoir is generally modulated by modulating valves on the two 600 mm dia. lines. The 450 mm line is set at a constant flow of 5.0 ML/d.

The combined total feed rate from the chlorinators is 452 kg/day for a total dosage of 7.5 mg/L to 30 mg/L based on flow rates of 60 and 15 ML/d

respectively. There is one common scale which supports two 900 kg cylinders. The limiting withdrawal rate is in the order of 435 kg/d which could limit the total dosages.

(b) Aggression Control

From 1980 to 1985, carbon dioxide and calcium hydroxide were dosed into the first cell of the reservoir. The carbon dioxide was initially discontinued and the lime dosages reduced due to continuing taste problems. Due to further taste problems, the lime was discontinued and a sodium silicate system was installed in 1988. The Loch Lomond aggression control system now consists of sodium silicate addition. The sodium silicate system consists of:

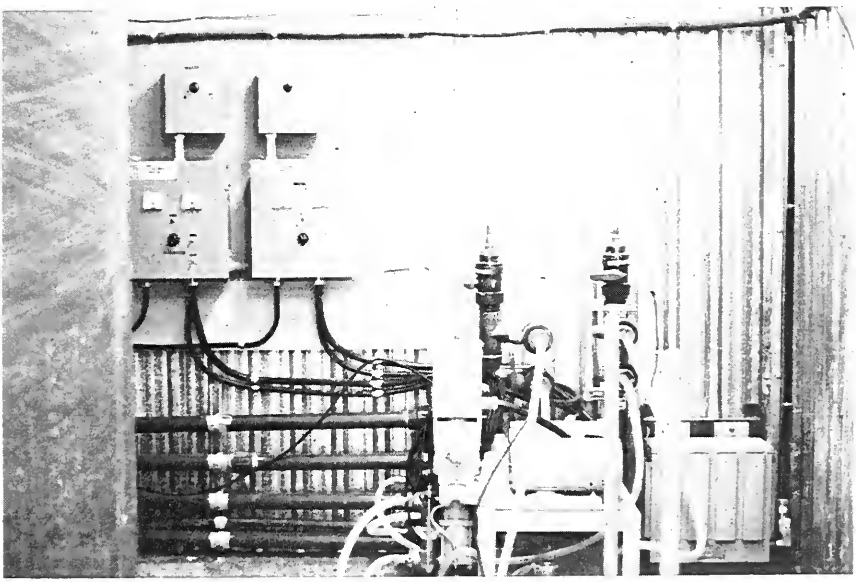
- four - 3,625 L fiberglass tanks
- two - 11,271 L/d metering pumps with variable speed controllers.

These components are located in a building next to the reservoir. Sodium silicate is dosed into a mixing channel located in the first cell of the reservoir. The metering pumps, one duty, and one standby, are paced off the summated flows in the pipelines. The maximum dosage capacity of the metering pump is 134.75 mg/L to 539 mg/L for 60.0 and 15.0 ML/d respectively. Based on 28.7 percent SiO_2 the maximum dosage capacity is 38.7 to 154.7 mg/l at flow rates of 60.0 and 15.0 ML/d.

C.4 Photographs

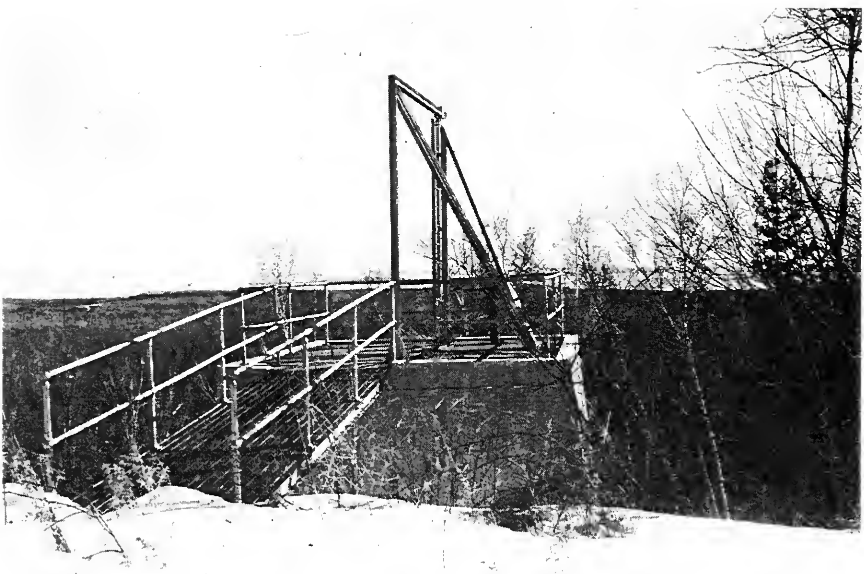
A series of photographs to illustrate major components and chemical feed systems follows this Section.

1. Sodium Silicate and Lime Silo, And CO2 Building

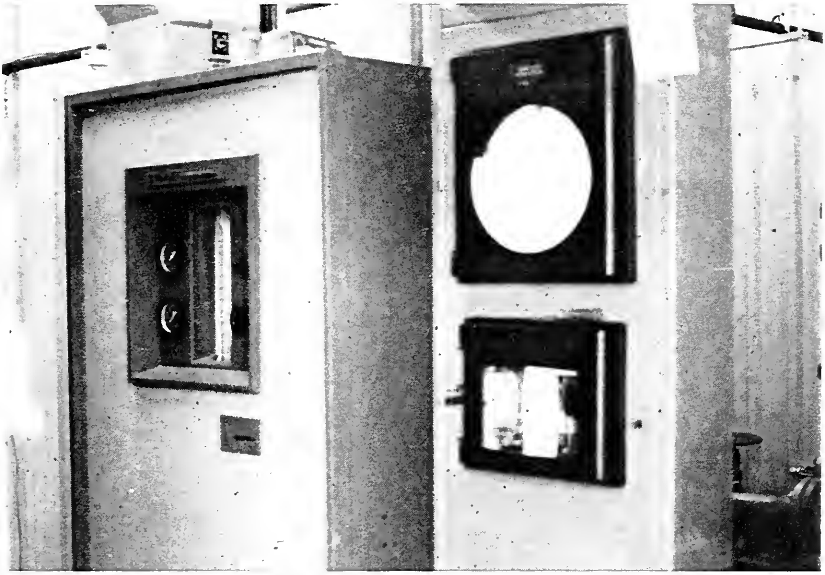


2. Sodium Silicate Metering System

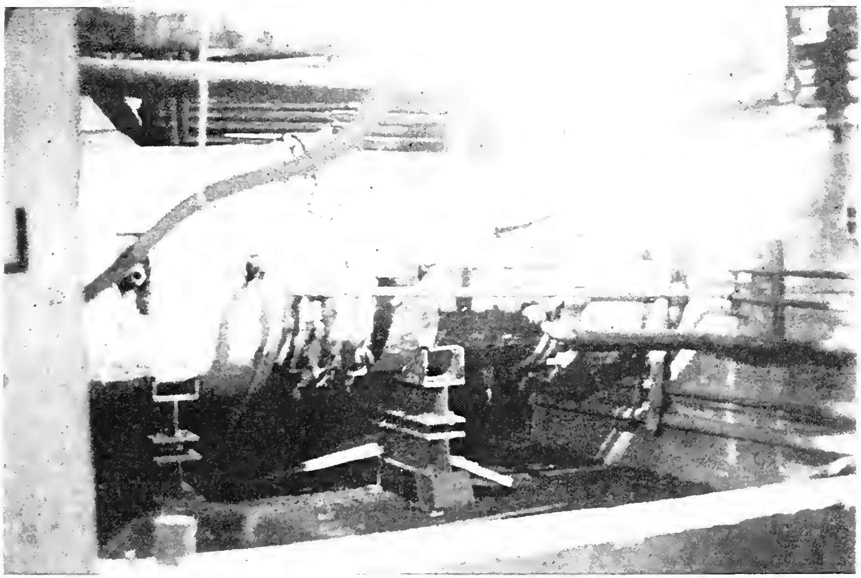
3. Screen Area



4. Screens



5. CO_2 Feeder Instruments



6. Metering Chamber

SECTION D - PLANT OPERATION

SECTION D - PLANT OPERATION

D.1 Description

(a) General

The Loch Lomond supply was placed into service on June 21, 1909. The supply system consists of a control dam on the Lake outlet to the Carp River, an intake pipe to a gatehouse at the shore, a tunnel connected to a forebay/screen chamber and multiple pipelines connected to a reservoir.

A lime/and carbon dioxide treatment system was installed in 1980, due to concerns on elevated levels of lead in the distribution system. This process reduces the aggressive nature of the raw water and hence the introduction of lead and other metals into solution. This system was discontinued due to taste problems and sodium silicate was put into operation in 1985.

The water is also disinfected with chlorine before entering the reservoir. The water supply system is located on an elevated plateau to the south of the City on Indian Reserve 52. The system operates entirely by gravity.

(b) Flow Control

Flow is controlled by two - 600 mm diameter and one - 450 mm diameter Ross valves. The valves are controlled by the level in the reservoir. These valves are located in a valve and meter chamber approximately 20 metres from the reservoir. The level in the reservoir is maintained to a range of 0.15 to 1.73 metres from top water level. The two 600 mm valves normally modulate on reservoir level and the 450mm line is set at a constant flow of 5.0 ML/d. The maximum flow through each of the 600 mm lines is in the order of 25.0 to 26.2 ML/d.

Two flow control needle valves (300 mm and 400 mm dia.) have been installed between the reservoir and the City. These valves permit reduction of pressure making it possible to transfer North Ward (Bare Point) water into the South Ward. These valves are not in operation when the transfer of water to the South Ward is not in practice.

(c) **Chemical Dosage Control**

Chlorine and sodium silicate are added year round.

(i) Chlorine

The City adjusts the chlorine levels in order to maintain a free chlorine residual of 1.3 mg/L entering the distribution system. The chlorine dosage is maintained automatically from a free chlorine residual measured 12 metres downstream from the point of chlorine addition. Each line entering the reservoir has its own separate chlorinator.

All chlorine feeds are taken from the same cylinder. Chlorine residuals are measured by amperometric titration. The City has reported that due to the oversizing and poor compensation of the Ross control valves, the chlorine residual deviates 0.3 mg/L to 0.5 mg/L from the desired value. Modulation of the chlorinators on the 600 mm lines is slow. Under peak or high demands, the 600 mm valves do modulate but cause "hunting". This can provide some excessive swings in chlorine residual.

It is noted in Table 3.2 in the Appendix that the free residual level measured after the water leaves the reservoir is occasionally greater than the free residual measured 12 meters downstream of the point of application (prior to entering the reservoir). This can only be explained by the poor compensation of the control valves or insufficient mixing at the point of measurement.

(ii) Sodium Silicate

Dosages vary between 6 and 14 mg/L, maintaining the pH between 8.5 and 9.5.

Changes in pH in the raw water are relatively small, and the corresponding sodium silicate dosages adjustments are also therefore small. The sodium silicate pump is manually adjusted in order to maintain the pH between 8.5 and 9.5.

The sodium silicate pump stroke adjustment for dosage is set manually and the pump speed is flow paced from the summation of all three meters. Daily silicate usage is determined by measuring the level drop in the four - 3,625 litre bulk storage tanks. City staff have also calibrated a 19 mm Neptune propeller type flow meter on the discharge side of the metering pumps and read the volume of product used every day to calculate the dosage from the totalizer located on the meter.

(d) **Quality Control Testing**

The following table lists pertinent information on the sample systems used at the Loch Lomond Plant.

Source	**Length m**	**Size mm**	**Flow L/min**	**Velocity m/s**	**Travel Time (min)**
Common connection on 1-600 & 2-450 mains outletting the reservoir	70	19	1.0	0.06	19.8

In Plant Monitoring

There are several instruments in place at the Loch Lomond Plant which continuously monitor the following water quality parameters.

- Turbidity at the inlet to the first reservoir cell.
- Free chlorine residual approximately 12 metres downstream from the point of application.
- Free chlorine residual from the 600 mm and the two - 450 mm discharge mains outletting from the second half of the reservoir.

The following Table gives a list of the additional monitoring tests performed at the Plant.

Test	Sample Point	Test Frequency	Testing Instrument
Free Chlorine Residual	discharge mains from second reservoir cell	daily	W&T Titrator
Turbidity*		daily	Hach 2100A
pH*		daily	Hach pH meter
Temperature		daily	
Hardness*		daily	Hach Spectrometer
Alkalinity*		daily	Hach Spectrometer
Bacteriological		weekly	by MOE
Phytoplankton		weekly	by MOE
Chlorinated Organics		monthly	by MOE
Iron		bimonthly	by MOE
Conductivity		bimonthly	by MOE
Chloride		bimonthly	by MOE
Colour		bimonthly	by MOE

*measured at Bare Point Lab.

The chlorination building is also equipped with trend recorders to handle the following analog inputs.

- Reservoir Chlorine Residual
- Reservoir Level
- Discharge Flow (3 per unit)
- pH

D.2 Operation and Process Concerns

(a) Intake

One of the most critical factors is the capacity of the existing intake at low Lake levels. The hydraulics of the system are governed by the obvert elevation of the tunnel at the shoreline gate chamber. At the minimum lake level recorded, the intake system is limited to a flow of 59.1 ML/d. This is also the approximate capacity of the existing pipelines from the tunnel outlet forebay to the reservoir. However, under higher lake elevations, higher flows can be transmitted.

During 1976-1977, an extended drought period caused the Lake levels to drop and required emergency measures to be prepared. These included laying a temporary polyethylene main into the lake and providing standby diesel powered pumping units to pump around the intake and forebay. The pumping units were designed to discharge directly into the wet well of the shoreline gatehouse. Actual implementation of these emergency measures was not, however, necessary.

The City recognized, however, that there were some uncertainties about the Lake capacity and that a thorough study of the drainage basin should be undertaken before a decision was made on the continued use of Loch Lomond as a water source.

The study was suggested because of the small, if any, surplus of estimated recharge potential over consumption as illustrated below:

- Estimated minimum annual recharge potential: 14,530 ML/year.
- Estimated normal annual recharge potential: 19,750 ML/year.
- Estimated annual average consumption: 15,830 ML/year.

The recharge potential was obtained from the Ontario Water Resources Commission Lakehead Area Study for Regional Water Supply and Pollution Control (1969).

(b) <u>Chlorine Residual</u>

The Ross control valves are oversized and exhibit poor sensitivity to small changes in reservoir level. This in turn leads to 0.3 to 0.5 mg/L deviations from the free chlorine residual setpoint (1.3mg/L). City staff have acknowledged this problem and have contemplated replacing the Ross valves with smaller electrically operated butterfly valves for flow control.

(c) <u>Source Protection</u>

The raw water may be adversely affected by activities such as logging in the Loch Lomond drainage area. This activity has taken place in the drainage area in the past but has currently been suspended. The effect of logging would be to increase the turbidity, dissolved organic content and to adversely effect snow melt, therefore having an impact on the recharge potential of the drainage area. With the lack of forestation, soil erosion would also be increased and hence have a negative impact on the Lake.

(d) <u>Taste and Odour</u>

It would appear that taste and odour problems in Loch Lomond water have resulted in the past from the chlorination of organic matter. In recent years, the lack of snow cover on the ice covered Lake has resulted in algae blooms. Such blooms are notorious for producing odorous compounds when chlorinated.

SECTION E - PLANT PERFORMANCE (PARTICULATE REMOVAL)

SECTION E - PLANT PERFORMANCE (PARTICULATE REMOVAL)

E.1 Turbidity Removal

(a) General

The general chemistry of the Loch Lomond water is shown in Table 1 in Section A of this Report. It can be seen from the following Table 3 that the raw water turbidities vary over a narrow range with March being the lowest month of the year.

Of all characteristics which give an indication of poor water quality, turbidity is considered as one of the most important. It has been shown in many studies that the particulates responsible for turbidity can harbour bacteria and other hazardous materials and shield them from disinfection. It is for this reason that the Ontario drinking water objectives have a maximum acceptable concentration of 1 NTU for turbidity, while lower levels are preferable. A water treatment plant should be designed to maintain a year round low effluent turbidity regardless of the seasonal variations in raw water quality.

The raw water from Loch Lomond is not treated using a coagulant or filtration. Chlorination for disinfection and sodium silicate addition for aggression control are the only treatment methods carried out at this location. The process is discussed in more detail in Section F. Since the water is not treated by coagulation or filtration, the turbidity of water entering the distribution system is dependent upon the turbidity of the water in the Lake. The treated water is generally of slightly higher turbidity than the raw due to the addition of sodium silicate. Occasionally the treated water does show a turbidity greater than 1.0 FTU, but it generally stays within the range of 0.4 to 0.6 FTU, with a low of 0.23 FTU and a high of 1.1 FTU. From the viewpoint of particulates, the water from Loch Lomond generally therefore meets the Ontario Drinking Water Objectives.

If logging activities around the Lake are resumed, however, it would be expected that the particulates in the water would increase, due to the resulting debris and soil erosion.

(b) Sampling System

The turbidity of the raw water is analyzed continuously and recorded using a Hach 1720A Turbidimeter at the raw water inlet to the reservoir. The treated water is monitored daily for particulate levels with a Hach 2100A laboratory turbidimeter at the Bare Point Plant. The sample analyzed is a grab sample.

Both turbidimeters are routinely calibrated using a 0.51 NTU formazin standard. With such equipment and calibration procedures it is our opinion that the results are accurate and valid.

(c) Particulate Removal Efficiency

The Loch Lomond plant generally treats water of low turbidity and although the treatment chemicals increase the turbidity levels, they infrequently exceed 1.0 NTU. When higher turbiditer does occur however, it is not possible to reduce them prior to discharge to the distribution system.

TABLE 3
Loch Lomond

1984-1986	**Raw Turbidity (FTU)**		
	Max.	**Min.**	**Avg.**
January	0.54	0.28	0.35
February	0.61	0.26	0.38
March	0.38	0.24	0.29
April	0.56	0.26	0.36
May	1.22	0.31	0.49
June	0.92	0.34	0.45
July	0.97	0.43	0.55
August	1.25	0.47	0.74
September	0.97	0.42	0.54
October	0.66	0.45	0.52
November	0.67	0.39	0.46
December	0.63	0.32	0.47

Figures obtained from Thunder Bay Plant data.

E.2 Treatability Testing

(a) Pilot Plant Study

In April 1985, Proctor & Redfern undertook treatability studies with the pilot plant located at the Loch Lomond facility. The details of the report can be read in its entirety in "A Study of Alternative Water Supplies", The Corporation of the City of Thunder Bay (Proctor & Redfern, 1985).

The objectives of the study were to:

- confirm the viability of the Direct Filtration process to treat the Loch Lomond water

- estimate chemical dosage rates

- ascertain filter run times under varying flows and chemical dosage rates

The pilot program was run over a period of 3 months. The two filters were operated at rates of 9 m/hr, 12 m/hr and 18 m/hr, permitting a direct comparison of performance at a fixed chemical dosage rate.

A typical analysis of raw water quality was as follows:

pH	7.0 mg/L
alkalinity	20 mg/L
hardness	25 mg/L
turbidity	0.5 N.T.U.
colour	20 T.C.U.
modified	
aggression index	9.7

Analysis of Results

Several runs at the beginning of the trial failed due to high filter rates and several were repeated to detect reasons for turbidity breakthrough.

From a review of the results, the following conclusions and comments can be made:

- Filtrate colour less than 5 T.C.U. can be achieved using Alum as sole coagulant at dosage rates in the order of 20 mg/L. However, filter run times were unacceptable.

- The use of polymers as filter aids to the Alum resulted in run times in excess of 24 hours for filter rates of 9 m/hr.

- Generally, filter rates of 12 m/hr. failed due to turbidity breakthrough. Later in the Study, the filter columns were changed to have both columns with a depth of 900 mm of anthracite, one with anthracite of

0.85 mm effective size and the other column with an effective size of 1.0 mm. This latter media achieved a 23 hour run which is still, however, marginal.

Direct filtration therefore appeared to be viable form of treatment for Loch Lomond water at the filter rate of 9 m/hr and utilizing chemical dosages of:

Primary Coagulant	Alum at 20 mg/L
Coagulant Aid	Allied Colloids LT20 at 0.2 mg/L or
	Allied Colloids LT22S at 0.25 mg/L or
	Alchem 28 at 0.20 mg/L

Since 9 m/hr is a relatively low filter rate and would require correspondingly larger filters, further work on pretreatment methods would be desirable to determine the optimum process. While a direct filtration plant is still the most cost effective system, it may be necessary to consider full treatment with provision for a by-pass for direct filtration when raw water quality is suitable.

E.3 Optimum Removal Strategies

The plant at Loch Lomond does not include any treatment process for particulate removal. The addition of sodium silicate for aggression control actually increases the particulates present in the water. In order to reduce the turbidity, colour and dissolved organics in the water, it would be necessary to provide a minimum of filtration as a means of water treatment. The study carried out by Proctor and Redfern in 1984 showed that it was possible to treat the water by direct filtration, although it may be necessary to provide full treatment at certain times. It has previously been recommended that the Loch Lomond supply be made redundant and that Bare Point be made the sole source of potable water for the City of Thunder Bay. This was due to a number of factors, including:

(a) The raw water from Lake Superior has lower nutrients and organics compared to that of Loch Lomond.

(b) Lake Superior does not require aggression treatment.

(c) All the treatment operations would be in one location, leading to the lower operating costs, higher efficiency and better overall control of the waterworks system.

(d) The City does not have control over the Loch Lomond catchment area.

For a more detailed review of this subject, reference should be made to The Study on Alternative Water Supplies for the City of Thunder Bay, Proctor and Redfern Group, 1985.

SECTION F- PLANT PERFORMANCE (DISINFECTION)

SECTION F - PLANT PERFORMANCE (DISINFECTION)

F.1 Disinfection Practices

(a) General

The water from Loch Lomond is chlorinated as it enters the reservoir. The free chlorine level is generally around 1.5 mg/L to 2.5 mg/L as it leaves the reservoir and 1.3 mg/L as it enters the distribution system. The water has a significant chlorine demand and this is discussed in detail in the following Part 3 (b) of this Section.

(b) Measurement System

The free chlorine residual at Loch Lomond is continuously analyzed with a Wallace and Tiernan chlorine residual analyzer. The sampling point is located 12 metres downstream of the application point in the respective discharge mains and it is noted that the free residual downstream of the reservoir occasionally increases. Since no further chlorine is added, this anomaly suggests that the sampling point does not represent a homogenous sample or that poor control valve operation accounts for the increased levels.

A second sample from the first half of the reservoir is also continuously monitored to give the free chlorine residual of the water as it is about to enter the distribution system. In addition, a daily free chlorine residual grab sample is obtained from a sample line connected to the one 600 mm and two 450 mm pipelines from the second half of the reservoir. Analysis of this sample is carried out by a Wallace and Tiernan Chlorine residual titrator, located in the Bare Point Laboratory.

F.2 Disinfection Efficiency

The raw water from Loch Lomond contains fairly high dissolved organic carbon levels of 13 mg/L (see Table 1). Such levels produce a chlorine demand and require a fairly high chlorination level in order to maintain a free residual chlorine throughout the system.

The treated water has a pH in the range of 8.5 to 9.0. At this pH, the free chlorine residual is predominantly in the form of hypochlorite rather than the more effective hypochlorous acid and as a result the disinfection ability is reduced.

The fecal and total coliforms appear to be destroyed by the level of disinfection carried out at Loch Lomond, as shown in Table 4. Some of the microorganisms that are more resistant to disinfection by chlorine have, however, been found in the distribution system. These included nematodes and protozoa, although it was not reported if these microbes were dead or alive upon inspection. One other factor which must also be considered is the long retention time between Loch Lomond and the distribution system. Based on average flow, this time is just over 6 hours. This long period enables even a low strength disinfectant to provide adequate protection.

Giardia cysts may be present in this water supply. Although none has been reported, they may appear in this source if wildlife is allowed to colonize the area. These cysts are extremely resistant to disinfection and are best removed by a complete treatment system including filtration.

Since a pH of 8.5 to 9.0 is desirable to reduce the aggressive nature of water, the best method of disinfection would be to form chloramines. Monochloramine is the desired constituent in the chloroamine reaction and is fortunate in this case that the optimum condition for monochloramine formations is pH of 8.4. This enables proper disinfection without the taste problem that would arise if dichloramines were able to form.

Although the use of monochloroamine, concentration for concentration, will give a lower disinfection efficiency than even the hypochlorite, it will lead to a lower formation of chlorinated by-products and, given the residence time of water in the system, will act as an effective disinfectant.

TABLE 4

Bacteriological Testing - Loch Lomond

(1983, 1984, 1986)

	Total Coliform		Fecal Coliform		Fecal Streptococcu	
	Raw	Treated	Raw	Treated	Raw	Trea
January	<4-4	abs	<2-2.66	abs	<2-2.66	abs
February	<4-4	abs	<2-4	abs	2.4	abs
March	<4-4	abs	<2-3.5	abs	<2-3.5	abs
April	<4-5	abs	<2-3.5	abs	<2-2.4	abs
May	<4-4	abs	<2-2	abs	<2-2	abs
June	4-75	abs	<2-3	abs	<2-76.5	abs
July	<4-<6.8	abs	<2-2.8	abs	<2-3.6	abs
August	<4-430	abs	<2-2	abs	<2-<3	abs
September	<4-99	abs	<2-2	abs	<2-<2.6	abs
October	<4.9	abs	<2-2	abs	<2-2	abs
November	<4.9	abs	<2-2	abs	<2-2	abs
December	<4-4	abs	<2-2	abs	<2-2	abs

F.3 Chlorinated By-Products Formation

(a) Current Requirements

Chlorinated by-products are produced in virtually every system where chlorine is used as the method of disinfection. The formation of these products is due to the reaction of chlorine with organic compounds present in the water. This can give rise to several halogenated organics. One of these is trihalomethanes, THM. The Ontario Ministry of Environment guideline for THMs in drinking water is 350 ug/L.

The results of the Drinking Water Surveillance Programme (DWSP) show that THM (trihalomethane) formation is fairly high, averaging 220 ug/L and peaking at 308 ug/L. Although the Ministry of the Environment guideline is 350 ug/L, some action should be considered to reduce these levels since lower limits are being implemented in other jurisdictions.

The high level of chlorination is currently required in order to disinfect the raw water against the bacteria, algae, nematodes and protozoa that are present. In addition, the combination of large watermains and low water velocities under average demand conditions can lead to stagnant water, possible sedimentation in the pipes and creation of areas resistant to disinfection.

(b) Attainable Levels

The water from Loch Lomond has a considerable chlorine demand, approximately 1 to 1.5 mg/L. Some of the demand is due to the high organic content of the water, which could increase if logging activities around the lake were resumed. Such activity usually leads to elevated colour, phenol and total organic carbon levels. In order to reduce the effect to a minimum, further logging operations should not be allowed. As previously discussed the reactions between organics and chlorine can form THMs, and this has in fact occurred.

In order to reduce such formation, two methods could be acceptable. Either a coagulation, flocculation and filtration process could be installed (at a high capital cost) to remove the organics prior to reaction with chlorine, or an alternative method of disinfection could be used (at a lower cost). We believe that extensive capital expenditure is both unnecessary and inappropriate for disinfection, but would be needed for particulate removal.

It would appear from the results of the water chemistry and our understanding of the Loch Lomond system, that chloramination would be the most appropriate method of disinfection. The pH of the treated water would be ideal for chloramine treatment. In order to ensure proper monochloramine formation, it is recommended that pH adjustment occur prior to disinfection. The addition of ammonia and chlorine to the water at a pH of 8.5 to 9.0 ensures no dichloramine formation. At this pH, monochloramine requires approximately sixty minutes for proper disinfection. Since the residence time of water in the pipeline from the plant to the consumer is over six hours, we believe that proper disinfection would take place.

Such chloramination would be an excellent method of reducing the THM formation in the Loch Lomond water. Since no free chlorine exists, no reaction can occur between the chlorine and dissolved organics present in the water, and thus THM formation does not occur.

There are other methods of reducing THM formation such as ozonation, ultra violet irradiation and the use of chlorine dioxide but we do not believe that they would be as appropriate for this plant. The most feasible alternative might, however, be chlorine dioxide.

SECTION G - SHORT AND LONG TERM MODIFICATIONS

SECTION G - SHORT AND LONG TERM MODIFICATION

G.1 Description

(a) General

This Section includes feasible short and long term process modifications required to provide optimum disinfection and particulate removal. Optimization may be subject to other constraints imposed on the City such as economics, cashflow and manpower availability.

G.2 Source Protection

The City of Thunder Bay has already carried out significant source protection by negotiating with the Indian Band to limit fishing, swimming and logging activities near the intake. The band controls the area around the water intake and there is not a great deal of logging potential left in this area of the lake. In addition, some source protection is carried out by the Band. The City has good source protection on its portion of the lake by restricting public access. However, additional protection would be beneficial. We recommend that the City undertake a review of the Loch Lomond drainage area for quality and quantity of the supply. The catchment area should be assessed for the current and expected wildlife and human activities. These activities should be then be reviewed in order to eliminate the potential point and non-point pollution sources in the watershed.

In combination with the quality aspects of the above study, the potential and actual recharge ability of the drainage area should be reviewed. It was noted in Section D that the estimated minimum recharge potential of Loch Lomond is below the average yearly consumption.

G.3 Disinfection

The present method of disinfection is by chlorination and it has been shown that chlorination produces several byproducts, one of which is chlorinated organics. It is possible to reduce the current levels of THM by using chloramination to disinfect the Loch Lomond water.

We recommend that laboratory and pilot scale studies be undertaken to determine the effect of chloramination on the reduction of chlorinated organics. The study would involve laboratory scale trials in order to quantify the dosages and identify the point(s) of injection. This would then lead to a small scale study at the site. This would involve a small metering pump and a drum of aqua ammonia.

The cost of the laboratory study would be approximately \$5,000.

It may also be worth examining chlorine dioxide as a disinfectant in this water.

The cost of the pilot scale study would be approximately \$15,000. A large part of this would be attributable to analysis costs for THM's.

G.4 Control Valves

The existing Ross control valves are oversized and are very slow in compensating for changes in level in the reservoir. This in turn leads to substantial swings in chlorine residual, in the order of 0.3 to 0.5 mg/L below the chlorine residual setpoint of 1.3 mg/L. We understand that the chlorine analysers have been relocated to reduce the response time.

We recommend that the City investigate means of controlling the flow more accurately in response to changes in the reservoir level. This may require replacement of the existing valves with properly sized motorized butterfly valves. After this system is installed, the City staff should investigate the free chlorine residual anomalies at the two sample locations. If the discrepancy persists, then the initial sampling point should be located further downstream.

The cost may be minimal if valve compensation is a matter of tuning the hydraulic response of the existing valves. However if replacement of valves is the solution, then this may cost approximately $75,000.

G.5 Particulate Removal

Although Loch Lomond has low turbidity, values occasionally exceed 1.0 NTU. For this reason, coagulation, flocculation and filtration should be provided to treat the water.

Proctor and Redfern Limited have undertaken pilot plant studies. The study (Alternative Water Supplies for the City of Thunder Bay, 1985) recommended a viable treatment process for the Loch Lomond water.

The treatment process recommended included:

- fine screening
- rapid mix
- flocculation
- filtration
- corrosion control
- disinfection

Further studies may be necessary to determine the need for sedimentation at certain times of the year.

The cost of this plant in 1985 dollars was approximately $13,000,000, based on a rated capacity of 43,000 ML/day (9.5 million gallons per day).

G.6 Colour Removal

The raw water colour continuously exceeds the MOE Drinking Water Objective of 5 TCU. In order to comply with this objective, treatment of the raw water is necessary. Proctor and Redfern Limited undertook pilot studies in 1985 to verify unit processes that would be necessary to effectively reduce

the colour to below 5 TCU. These processes are the same as described in the preceding Section G5.

G.7 Long Term Use of Loch Lomond

Proctor and Redfern's 1985 study of Alternative Water Supplies recommended that the City of Thunder Bay be serviced exclusively by the Bare Point Plant located on Lake Superior. The major advantages cited in this Report were:

- Lake Superior is more secure in that all treatment facilities are on City owned land.
- The raw water quality in Lake Superior is considerably better in terms of having less colour, is less aggressive (corrosive) and lower in organics.
- Construction of a treatment facility at Loch Lomond may be difficult due to the rough nature of the terrain.
- Disposal of wastes from the Loch Lomond Plant will be more difficult due to the lack of proximity of sanitary sewers and greater difficulty of discharging decant from any settling process.
- Access to the plant in winter will be less reliable for personnel and chemical deliveries.
- All water treatment will be at one location which will lead to lower operating costs, greater efficiency and better overall control of the waterworks system.

Some of the disadvantages of a single supply at Bare Point are:

- It will be more difficult to expand to service a population beyond 120,000 if the current hydraulic gradient of 272.8 at the Plant cannot be exceeded. This gradient is necesary to limit over pressurization in

areas near the plant. This can be overcome by further watermain construction and the addition of pressure relief valves to the system.

- Upgrading of the existing plant and construction of additional facilities will be required to meet the total system requirements. This will cost approximately $2.0 million.

- It is also noted that with the option of expanding the Bare Point Plant and not building a new treatment facility at Loch Lomond, considerable capital costs in the order of $4.6 to $9.3 million in distribution system upgrading will be required.

It has been noted in a comparison of the amortized capital plus operating costs, however, that the alternative of expanding the Bare Point Plant is more economical over the long term.

APPENDIX A

TABLE 1

WATER PLANT OPTIMIZATION STUDY
"PLANT FLOWS"

TABLE 1.0: FLOWS (ML/d)

LOCH LOMOND

MOE WPOS PROTOCOL

		1986			1985			1984			1983		
		MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG
JAN	R T	49.87	20.50	32.15	50.05	33.06	35.36	44.61	31.30	34.33	49.22	23.85	33.79
FEB	R T	52.00	22.95	33.87	46.1	28.89	33.99	44.50	31.66	34.38	51.71	25.11	33.97
MAR	R T	51.23	22.65	34.15	45.75	30.27	34.85	44.66	31.29	33.98	51.17	23.24	33.85
APR	R T	51.93	17.99	31.22	50.66	26	33.98	44.68	29.87	36.29	49.52	22.38	33.86
MAY	R T	52.03	19.31	32.97	53.05	24.53	34.68	44.48	25.73	35.03	54.35	25.27	35.16
JUN	R T	52.18	25.63	35.59	51.85	27.93	37.12	49.43	26.66	35.98	52.97	24.85	36.58
JUL	R T	52.30	28.18	38.34	51.69	28.43	35.7	48.30	26.90	36.67	58.10	27.36	42.10
AUG	R T	51.70	27.28	36.65	52	29.98	36.61	50.58	33.16	39.05	55.04	36.25	43.49
SEP	R T	51.30	22.91	34.22	51	29.42	36.15	51.09	25.00	37.70	51.69	34.85	41.19
OCT	R T	49.96	22.79	31.99	50.68	23.5	34.49	48.87	30.12	34.94	50.44	33.72	39.51
NOV	R T	49.64	21.52	30.96	50.86	28.31	35.43	48.07	29.50	32.60	42.69	25.43	34.28
DEC	R T	48.07	21.09	31.18	51.98	22.73	32.38	47.75	34.05	38.13	45.81	29.95	34.21

* Both treated and raw data are the same for 1986, 1985, 1984, 1983.

TABLE 2

WATER PLANT OPTIMIZATION STUDY
"PARTICULATE REMOVAL SUMMARY"

TABLE 2.0: PARTICULATE REMOVAL SUMMARY-LOCH LOMOND **

MOE WPOS PROTOCOL

				1986			1985			1984	
			MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG
JAN	TURBIDITY (FTU)	R	0.520	0.230	0.300	0.630	0.280	0.380	0.470	0.340	0.380
		T	0.530	0.330	0.380	0.720	0.350	0.440	0.570	0.440	0.450
	Prime Coagulant (mg/L)										
	Coagulant Aid (mg/L)										
	Lime or Sod.Sil. (mg/l)		6.150	6.150	6.150	11.620	6.750	7.990	11.850	8.810	9.990
	Metal Res. (Al) (mg/L)	R									
		T									
	pH	R	7.280	7.010	7.320	7.600	7.330	7.430	7.450	7.000	7.200
		T	10.000	7.280	8.640	9.100	7.800	8.360	9.260	7.810	8.600
	Temperature (C)		2.000	2.000	2.000	2.000	2.000	2.000	4.000	2.000	2.900
FEB	TURBIDITY (FTU)	R	0.330	0.240	0.360	0.750	0.260	0.380	0.740	0.280	0.410
		T	0.530	0.290	0.460	0.480	0.270	0.360	0.620	0.330	0.460
	Prime Coagulant (mg/L)										
	Coagulant Aid (mg/L)										
	Lime or Sod.Sil. (mg/l)		6.150	6.150	6.150	10.330	7.890	9.510	11.260	7.520	8.540
	Metal Res. (Al) (mg/L)	R									
		T									
	pH	R	7.390	7.070	7.220	8.700	7.300	7.360	7.300	6.980	7.200
		T	10.200	7.200	9.410	8.700	7.840	8.023	9.600	7.400	8.800
	Temperature (C)		2.000	2.000	2.000	2.000	2.000	2.000	4.000	3.000	3.600
MAR	TURBIDITY (FTU)	R	0.300	0.250	0.280	0.420	0.250	0.280	0.420	0.210	0.300
		T	0.350	0.250	0.280	0.430	0.350	0.370	0.380	0.220	0.300
	Prime Coagulant (mg/L)										
	Coagulant Aid (mg/L)										
	Lime or Sod.Sil. (mg/l)		6.150	6.150	6.150	12.970	9.650	10.970	9.660	7.600	8.670
	Metal Res. (Al) (mg/L)	R									
		T									
	pH	R	7.350	7.080	7.090	7.800	7.280	7.420	7.380	7.140	7.250
		T	9.800	9.400	9.440	8.700	7.730	8.310	9.600	8.500	9.200
	Temperature (C)		2.000	2.000	2.000	3.000	2.000	2.520	4.000	3.000	3.950
APR	TURBIDITY (FTU)	R	0.600	0.300	0.420	0.590	0.230	0.310	0.480	0.240	0.340
		T	0.820	0.320	0.460	0.920	0.340	0.400	0.550	0.270	0.360
	Prime Coagulant (mg/L)										
	Coagulant Aid (mg/L)										
	Lime or Sod.Sil. (mg/l)		6.150	6.150	6.150	11.000	4.630	6.240	9.810	7.360	8.780
	Metal Res. (Al) (mg/L)	R									
		T									
	pH	R	7.040	6.490	7.450	7.400	7.270	7.310	7.300	7.200	7.270
		T	9.900	9.300	9.410	8.800	7.850	8.360	9.600	7.200	8.760
	Temperature (C)		4.000	2.000	3.000	6.000	3.000	4.350	5.000	4.000	4.300

MOE WPOS PROTOCOL

TABLE 2.0 (cont'd)			1986			1985			1984		
			MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG
MAY	TURBIDITY (FTU)	R	2.300	0.300	0.700	0.780	0.300	0.410	0.570	0.320	0.370
		T	1.000	0.480	0.610	0.660	0.370	0.450	0.520	0.370	0.430
	Prime Coagulant (mg/L)										
	Coagulant Aid (mg/L)										
	Lime or Sod.Sil. (mg/l)		6.150	6.150	6.150	6.150	6.150	6.150	11.060	6.930	8.760
	Metal Res. (Al) (mg/L)	R									
		T									
	pH	R	7.400	6.700	7.250	7.430	7.180	7.290	7.380	7.070	7.260
		T	9.800	9.000	9.460	8.800	7.200	8.190	9.800	9.000	9.200
	Temperature (C)		7.000	4.000	4.810	9.000	6.000	6.600	10.000	5.000	7.200
JUN	TURBIDITY (FTU)	R	1.190	0.300	0.650	0.650	0.380	0.450	-	-	0.250
		T	0.730	0.420	0.520	0.670	0.430	0.550	-	-	0.250
	Prime Coagulant (mg/L)										
	Coagulant Aid (mg/L)										
	Lime or Sod.Sil. (mg/l)		6.150	6.150	6.150	6.150	6.150	6.150	13.650	7.790	10.170
	Metal Res. (Al) (mg/L)	R									
		T									
	pH	R	7.470	7.150	7.300	7.590	7.270	7.400	-	-	7.300
		T	9.600	9.000	9.400	9.100	7.720	8.500	9.600	8.800	9.360
	Temperature (C)		12.000	7.000	8.810	12.000	9.000	9.680	12.000	9.000	10.400
JUL	TURBIDITY (FTU)	R	0.850	0.400	0.530	0.770	0.400	0.512	1.300	0.480	0.620
		T	1.200	0.500	0.630	1.050	0.480	0.600	0.830	0.450	0.460
	Prime Coagulant (mg/L)										
	Coagulant Aid (mg/L)										
	Lime or Sod.Sil. (mg/l)		6.150	6.150	6.150	6.150	6.150	6.150	10.940	6.270	8.290
	Metal Res. (Al) (mg/L)	R									
		T									
	pH	R	7.340	7.020	7.240	7.500	6.930	7.230	7.240	6.850	7.110
		T	9.400	5.800	8.770	8.850	7.240	8.220	9.600	8.790	9.310
	Temperature (C)		12.000	10.000	11.300	14.000	11.000	12.860	15.000	13.000	14.800
AUG	TURBIDITY (FTU)	R	2.200	0.530	1.080	0.630	0.420	0.520	0.920	0.460	0.620
		T	0.750	0.510	0.610	0.770	0.530	0.580	0.650	0.500	0.600
	Prime Coagulant (mg/L)										
	Coagulant Aid (mg/L)										
	Lime* (mg/l)		20.220	16.040	18.100	6.150	6.150	6.150	13.860	8.150	11.220
	Metal Res. (Al) (mg/L)	R									
		T									
	pH	R	7.290	6.970	7.080	7.640	7.100	7.290	9.700	7.090	7.300
		T	9.600	8.500	9.020	7.640	7.450	7.578	9.900	9.100	9.632
	Temperature (C)		17.000	11.000	12.100	19.000	14.000	14.950	19.000	13.000	14.800

MOE WPOS PROTOCOL

TABLE 2.0 (cont'd)				1986			1985			1984		
				MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG
SEP	TURBIDITY (FTU)		R	0.600	0.480	0.520	1.100	0.440	0.520	1.200	0.330	0.570
			T	2.300	0.470	0.570	0.720	0.520	0.620	0.720	0.520	0.650
	Prime Coagulant	(mg/L)										
	Coagulant Aid	(mg/L)										
	Lime*	(mg/l)		20.630	14.760	17.740	6.150	6.150	6.150	14.630	9.900	13.410
	Metal Res. (Al)	(mg/L)	R									
			T									
	pH		R	7.950	6.980	7.380	7.560	7.130	7.400	7.730	7.340	7.600
			T	9.700	9.100	7.950	8.880	6.630	8.170	9.400	7.890	8.600
	Temperature	(C)		16.000	12.000	12.950	16.000	13.000	15.110	16.000	14.000	15.300
OCT	TURBIDITY (FTU)		R	0.570	0.480	0.510	0.680	0.400	0.513	0.720	0.480	0.550
			T	0.700	0.430	0.490	0.780	0.460	0.590	0.760	0.550	0.630
	Prime Coagulant	(mg/L)										
	Coagulant Aid	(mg/L)										
	Lime*	(mg/l)		17.900	12.130	14.070	6.150	6.150	6.150	14.470	9.720	11.780
	Metal Res. (Al)	(mg/L)	R									
			T									
	pH		R	7.520	7.260	7.370	7.560	7.110	7.360	9.900	7.420	7.500
			T	9.400	7.800	7.760	8.920	6.720	7.610	9.400	7.580	8.500
	Temperature	(C)		11.000	7.000	8.810	17.000	7.000	9.810	12.000	8.000	10.200
NOV	TURBIDITY (FTU)		R	0.850	0.450	0.540	0.500	0.310	0.340	0.670	0.410	0.510
			T	0.830	0.470	0.560	0.680	0.330	0.450	0.750	0.520	0.560
	Prime Coagulant	(mg/L)										
	Coagulant Aid	(mg/L)										
	Lime*	(mg/l)		19.120	10.120	16.180	6.150	6.150	6.150	12.260	9.310	10.850
	Metal Res. (Al)	(mg/L)	R									
			T									
	pH		R	7.440	7.180	7.340	7.700	7.360	7.490	7.600	7.310	7.410
			T	9.500	8.600	7.910	8.650	7.530	7.990	8.700	7.580	8.400
	Temperature	(C)		8.000	3.000		7.000	4.000	5.500	8.000	5.000	6.200
DEC	TURBIDITY (FTU)		R	0.690	0.280	0.540	0.450	0.300	0.360	0.760	0.370	0.500
			T	0.740	0.390	0.450	0.560	0.300	0.420	0.640	0.440	0.500
	Prime Coagulant	(mg/L)										
	Coagulant Aid	(mg/L)										
	Lime*	(mg/l)		15.350	9.130	12.180	6.150	6.150	6.150	10.690	7.110	4.600
	Metal Res. (Al)	(mg/L)	R									
			T									
	pH		R	7.490	7.240	7.340	7.330	7.250	7.330	9.800	7.820	7.250
			T	9.700	6.950	7.860	8.020	7.560	7.740	9.800	6.760	7.500
	Temperature	(C)		3.000	2.000	2.330	4.000	2.000	2.650	4.000	2.000	2.900

* Sodium Silicate is used instead of Lime for 1986 in these months

** For all other months, Lime is used in 1986 and Sodium Silicate for 1984 and 1985

TABLE 2.1: PARTICULATE REMOVAL PROFILE (JAN/84)-LOCH LOMOND
MOE WPOS PROTOCOL

DATE	TURBIDITY (NTU)				LIME DOSAGE mg/L	FILTER AID mg/L	METAL RES. (Al) (mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.			RAW	TREATED	RAW	TREATED	(C)
1	-	-	-	-	10.09	-	-	-	-	-	-
2	-	-	-	-	10.09	-	-	-	-	-	-
3	0.37	-	-	0.44	11.85	-	-	-	7.25	8.84	4.0
4	0.41	-	-	0.57	10.29	-	-	-	7.28	8.85	4.0
5	0.39	-	-	0.45	10.18	-	-	-	7.20	8.05	4.0
6	0.36	-	-	0.46	10.00	-	-	-	7.28	8.91	3.0
7	-	-	-	-	10.00	-	-	-	-	-	-
8	-	-	-	-	10.00	-	-	-	-	-	-
9	0.34	-	-	0.44	10.10	-	-	-	7.29	8.36	3.0
10	0.37	-	-	0.45	9.77	-	-	-	7.24	9.01	3.0
11	0.38	-	-	0.45	10.41	-	-	-	7.30	8.73	3.0
12	0.47	-	-	0.48	10.66	-	-	-	7.20	9.09	2.0
13	0.35	-	-	0.47	11.13	-	-	-	7.10	8.97	2.0
14	-	-	-	-	11.13	-	-	-	-	-	-
15	-	-	-	-	11.13	-	-	-	-	-	-

DATE	TURBIDITY (NTU)				LIME DOSAGE mg/L	FILTER AID mg/L	METAL RES. (Al) (mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.			RAW	TREATED	RAW	TREATED	(C)
16	0.43	-	-	0.45	10.87	-	-	-	7.20	8.68	3.0
17	0.38	-	-	0.47	9.70	-	-	-	7.30	7.89	2.0
18	0.42	-	-	0.52	11.80	-	-	-	7.30	8.93	2.0
19	0.48	-	-	0.47	10.74	-	-	-	7.35	8.63	2.0
20	0.40	-	-	0.39	9.16	-	-	-	7.40	8.22	2.0
21	-	-	-	-	9.16	-	-	-	-	-	-
22	-	-	-	-	9.16	-	-	-	-	-	-
23	0.40	-	-	0.46	9.05	-	-	-	7.00	7.81	3.0
24	0.44	-	-	0.52	9.07	-	-	-	7.40	8.91	3.0
25	0.41	-	-	0.47	9.20	-	-	-	7.35	-	3.0
26	-	-	-	-	10.02	-	-	-	-	8.97	3.0
27	0.40	-	-	0.46	9.00	-	-	-	7.45	8.27	3.0
28	-	-	-	-	9.00	-	-	-	-	-	-
29	-	-	-	-	9.00	-	-	-	-	-	-
30	0.42	-	-	0.49	8.81	-	-	-	7.30	8.44	3.0
31	0.45	-	-	0.47	9.03	-	-	-	7.20	9.26	3.0

* Total Fe Res for month 0.10 mg/L, Avg per day 0.05 mg/L

TABLE 2.1: PARTICULATE REMOVAL PROFILE (APRIL/84)-LOCH LOMOND

MOE WPOS PROTOCOL

DATE	TURBIDITY (NTU)				LIME DOSAGE mg/L	FILTER AID mg/L	METAL RES. (Al) (mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.			RAW	TREATED	RAW	TREATED	(C)
1	-	-	-	-	8.77	-	-	-	-	-	-
2	0.24	-	-	0.27	8.48	-	-	-	7.30	9.30	4.0
3	0.30	-	-	0.33	7.36	-	-	-	7.22	9.60	4.0
4	0.31	-	-	0.32	-	-	-	-	7.23	9.50	4.0
5	0.34	-	-	0.27	8.52	-	-	-	7.20	-	4.0
6	0.27	-	-	0.29	8.69	-	-	-	7.27	9.30	4.0
7	-	-	-	-	8.69	-	-	-	-	-	-
8	-	-	-	-	8.69	-	-	-	-	-	-
9	0.48	-	-	0.38	8.80	-	-	-	7.25	9.30	4.0
10	0.32	-	-	0.38	8.96	-	-	-	7.25	9.50	4.0
11	0.27	-	-	0.33	8.99	-	-	-	7.26	9.50	4.0
12	0.44	-	-	0.35	9.58	-	-	-	7.28	9.40	4.0
13	0.32	-	-	0.42	9.13	-	-	-	7.26	9.40	4.0
14	-	-	-	-	9.13	-	-	-	-	-	-
15	-	-	-	-	9.13	-	-	-	-	-	-

DATE	TURBIDITY (NTU)				LIME DOSAGE mg/L	FILTER AID mg/L	METAL RES. (Al) (mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.			RAW	TREATED	RAW	TREATED	(C)
16	0.37	-	-	0.43	9.42	-	-	-	7.25	9.50	4.0
17	0.44	-	-	0.55	9.25	-	-	-	7.20	9.60	4.0
18	0.48	-	-	0.51	9.81	-	-	-	7.20	9.50	4.0
19	0.48	-	-	0.42	8.50	-	-	-	7.21	9.60	4.0
20	-	-	-	-	8.50	-	-	-	-	-	-
21	-	-	-	-	8.50	-	-	-	-	-	-
22	-	-	-	-	8.50	-	-	-	-	-	-
23	0.34	-	-	-	8.50	-	-	-	7.25	-	-
24	0.34	-	-	0.32	7.97	-	-	-	7.29	9.40	5.0
25	0.32	-	-	0.35	8.94	-	-	-	7.30	9.60	5.0
26	0.33	-	-	0.37	8.96	-	-	-	7.28	9.50	5.0
27	0.33	-	-	0.33	8.95	-	-	-	-	9.30	5.0
28	-	-	-	-	8.95	-	-	-	-	-	-
29	-	-	-	-	8.95	-	-	-	-	-	-
30	0.39	-	-	0.58	8.13	-	-	-	7.24	9.30	5.0

* Total Fe Res for month 0.10 mg/L, Avg per day 0.05 mg/L

TABLE 2.1: PARTICULATE REMOVAL PROFILE (JULY/84)-LOCH LOMOND
MOE WPOS PROTOCOL

DATE	TURBIDITY (NTU)				LIME DOSAGE mg/L	FILTER AID mg/L	METAL RES. (Al) (mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.			RAW	TREATED	RAW	TREATED	(C)
1	0.79	-	-	0.83	8.71	-	-	-	6.93	8.79	13.0
2	-	-	-	-	10.94	-	-	-	-	-	13.0
3	-	-	-	-	8.77	-	-	-	-	-	13.0
4	-	-	-	-	8.77	-	-	-	-	-	13.0
5	0.48	-	-	-	8.77	-	-	-	-	-	13.0
6	-	-	-	0.55	10.46	-	-	-	-	-	13.0
7	-	-	-	-	10.46	-	-	-	-	-	13.0
8	-	-	-	-	10.46	-	-	-	-	-	13.0
9	-	-	-	-	8.00	-	-	-	-	-	14.0
10	-	-	-	-	9.00	-	-	-	-	-	14.0
11	-	-	-	-	9.00	-	-	-	-	-	14.0
12	-	-	-	-	9.00	-	-	-	-	-	14.0
13	-	-	-	-	7.87	-	-	-	-	-	15.0
14	-	-	-	-	7.87	-	-	-	-	-	15.0
15	-	-	-	-	8.05	-	-	-	-	-	15.0

DATE	TURBIDITY (NTU)				LIME DOSAGE mg/L	FILTER AID mg/L	METAL RES. (Al) (mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.			RAW	TREATED	RAW	TREATED	(C)
16	-	-	-	-	8.05	-	-	-	-	-	15.0
17	-	-	-	-	8.05	-	-	-	-	-	15.0
18	-	-	-	-	8.05	-	-	-	-	-	15.0
19	-	-	-	-	7.62	-	-	-	-	-	15.0
20	-	-	-	-	7.62	-	-	-	-	-	15.0
21	-	-	-	-	7.62	-	-	-	-	-	15.0
22	-	-	-	-	**	-	-	-	-	-	15.0
23	-	-	-	-	6.27	-	-	-	-	-	-
24	-	-	-	-	8.33	-	-	-	6.85	9.30	15.0
25	1.30	-	-	0.47	7.26	-	-	-	7.14	9.60	15.0
26	0.52	-	-	0.45	8.57	-	-	-	7.17	-	15.0
27	0.52	-	-	0.47	7.60	-	0.010	-	7.15	9.50	15.0
28	0.59	-	-	0.59	7.60	-	-	-	-	-	15.0
29	-	-	-	-	7.60	-	-	-	-	-	-
30	-	-	-	-	7.60	-	-	-	-	-	-
31	1.10	-	-	0.58	6.93	-	-	-	7.24	9.40	15.0

* Fe Res - Avg per day o.68 mg/L. Total for month 2.05 mg/L

** LIME FEED INOPERATIONAL AS OF 3:10 JULY 22ND

TABLE 2.1: PARTICULATE REMOVAL PROFILE (OCT/84)-LOCH LOMOND
MOE WPOS PROTOCOL

DATE	TURBIDITY (NTU)				LIME DOSAGE mg/L	FILTER AID mg/L	METAL RES. (Al) (mg/L)		pH		TEMP (C)
	RAW	SET.	FILTER	TREAT.			RAW	TREATED	RAW	TREATED	
1	0.55	-	-	0.76	11.76	-	-	-	7.70	8.50	12.0
2	0.63	-	-	0.62	14.06	-	-	-	7.71	8.36	12.0
3	0.55	-	-	0.63	11.01	-	-	-	7.60	8.50	12.0
4	0.52	-	-	0.75	11.24	-	-	-	7.68	8.58	12.0
5	0.48	-	-	0.55	12.29	-	-	-	7.60	7.76	11.0
6	-	-	-	-	12.29	-	-	-	-	-	-
7	-	-	-	-	12.29	-	-	-	-	-	-
8	-	-	-	-	12.29	-	-	-	-	-	-
9	0.50	-	-	0.72	10.96	-	-	-	7.64	8.10	10.0
10	0.52	-	-	0.68	10.61	-	-	-	7.56	8.20	10.0
11	0.58	-	-	0.63	11.52	-	-	-	7.58	8.50	10.0
12	0.53	-	-	0.63	14.47	-	-	-	7.60	8.67	10.0
13	-	-	-	-	14.47	-	-	-	-	-	-
14	-	-	-	-	14.47	-	-	-	-	-	-
15	-	-	-	-	12.10	-	-	-	-	-	10.0

DATE	TURBIDITY (NTU)				LIME DOSAGE	FILTER AID	METAL RES. (Al) (mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.	mg/L	mg/L	RAW	TREATED	RAW	TREATED	(C)
16	0.61	-	-	0.63	10.95	-	-	-	7.43	8.28	10.0
17	0.56	-	-	0.67	12.79	-	-	-	7.50	8.80	9.0
18	0.67	-	-	0.73	10.29	-	-	-	7.48	8.57	9.0
19	-	-	-	-	12.70	-	-	-	-	-	9.0
20	-	-	-	-	12.70	-	-	-	-	-	-
21	-	-	-	-	12.70	-	-	-	-	-	-
22	0.72	-	-	0.63	11.01	-	-	-	7.42	8.00	9.0
23	0.53	-	-	0.72	12.78	-	-	-	7.51	8.40	9.0
24	0.61	-	-	0.67	11.81	-	-	-	7.50	8.20	9.0
25	0.56	-	-	0.65	11.44	-	-	-	7.40	7.80	9.0
26	0.57	-	-	0.57	10.00	-	-	-	7.40	7.58	9.0
27	-	-	-	-	10.00	-	-	-	-	-	-
28	-	-	-	-	10.00	-	-	-	-	-	-
29	0.58	-	-	0.68	10.98	-	-	-	9.90	9.90	8.0
30	0.50	-	-	0.56	10.03	-	-	-	9.90	9.90	8.0
31	0.53	-	-	0.60	9.72				9.90	9.90	8.0

* Fe Res - Avg per day 0.05 mg/L

TABLE 2.1: PARTICULATE REMOVAL PROFILE (JAN/85)-LOCH LOMOND

MOE WPOS PROTOCOL

DATE	TURBIDITY (NTU)				SODIUM SILICATE	FILTER AID	METAL RES. (Al) (mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.	mg/L	mg/L	RAW	TREATED	RAW	TREATED	(C)
1	-	-	-	-	8.53	-	-	-	-	-	-
2	0.47	-	-	0.49	11.18	-	-	-	7.50	9.08	2.0
3	0.37	-	-	0.47	11.62	-	-	-	7.53	9.10	2.0
4	0.37	-	-	0.44	7.12	-	-	-	7.60	8.82	2.0
5	-	-	-	-	7.12	-	-	-	-	-	-
6	-	-	-	-	7.12	-	-	-	-	-	-
7	0.38	-	-	0.43	8.00	-	-	-	7.50	8.30	2.0
8	0.63	-	-	0.41	8.14	-	-	-	7.48	8.49	2.0
9	0.57	-	-	0.43	8.01	-	-	-	7.50	8.60	2.0
10	0.35	-	-	0.40	6.85	-	-	-	7.48	7.80	2.0
11	0.39	-	-	0.42	8.19	-	-	-	7.48	7.85	2.0
12	-	-	-	-	8.19	-	-	-	-	-	-
13	-	-	-	-	8.19	-	-	-	-	-	-
14	0.34	-	-	0.63	7.05	-	-	-	7.50	8.40	2.0
15	0.37	-	-	0.43	7.11	-	-	-	7.53	8.00	2.0

TABLE 2.1 (cont'd)

DATE	TURBIDITY (NTU)				SODIUM SILICATE	FILTER AID	METAL RES. (Al) (mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.	mg/L	mg/L	RAW	TREATED	RAW	TREATED	(C)
16	0.35	-	-	0.72	7.86	-	-	-	7.45	7.84	2.0
17	0.36	-	-	0.62	6.75	-	-	-	7.50	8.54	2.0
18	0.36	-	-	0.35	7.73	-	-	-	7.33	8.05	2.0
19	-	-	-	-	7.73	-	-	-	-	-	-
20	-	-	-	-	7.73	-	-	-	-	-	-
21	0.36	-	-	0.40	7.25	-	-	-	7.50	8.17	2.0
22	-	-	-	-	7.39	-	-	-	-	-	2.0
23	0.49	-	-	0.39	8.24	-	-	-	7.50	8.20	2.0
24	0.37	-	-	0.42	7.74	-	-	-	7.53	8.00	2.0
25	0.32	-	-	0.47	7.91	-	-	-	7.50	8.12	2.0
26	-	-	-	-	7.91	-	-	-	-	-	-
27	-	-	-	-	7.91	-	-	-	-	-	-
28	0.37	-	-	0.37	7.91	-	-	-	7.54	8.50	2.0
29	0.28	-	-	0.47	8.16	-	-	-	7.48	8.83	2.0
30	0.38	-	-	0.47	9.55	-	-	-	7.40	8.43	2.0
31	0.35	-	-	0.45	7.57	-	-	-	7.50	8.61	2.0

Total Fe Res for month 0.10 mg/L, Avg per day 0.05 mg/L

TABLE 2.1: PARTICULATE REMOVAL PROFILE (APRIL/85) LOCH LOMOND
MOE WPOS PROTOCOL

DATE	TURBIDITY (NTU)				SODIUM SILICATE	FILTER AID	METAL RES. (Al) (mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.	mg/L	mg/L	RAW	TREATED	RAW	TREATED	(C)
1	0.23	-	-	0.43	11.00	-	-	-	7.40	8.30	3.0
2	0.32	-	-	0.39	10.20	-	-	-	7.33	7.85	3.0
3	0.32	-	-	0.38	4.63	-	-	-	7.35	8.20	3.0
4	0.36	-	-	0.39	4.63	-	-	-	7.36	8.29	3.0
5	-	-	-	-	4.63	-	-	-	-	-	-
6	-	-	-	-	4.63	-	-	-	-	-	-
7	-	-	-	-	6.15	-	-	-	-	-	-
8	-	-	-	-	6.15	-	-	-	-	-	-
9	0.33	-	-	0.40	6.15	-	-	-	7.30	8.20	3.0
10		-	-	-	6.15	-	-	-	-	-	3.0
11	0.48	-	-	0.63	6.15	-	-	-	7.33	8.55	3.0
12	0.38	-	-	0.34	6.15	-	-	-	7.33	8.23	3.0
13	-	-	-	-	6.15	-	-	-	-	-	-
14	-	-	-	-	6.15	-	-	-	-	-	-
15	0.38	-	-	0.41	6.15	-	-	-	7.35	8.00	3.0

DATE	TURBIDITY (NTU)				SODIUM SILICATE mg/L	FILTER AID mg/L	METAL RES. (Al) (mg/L)		pH		TEMP (C)
	RAW	SET.	FILTER	TREAT.			RAW	TREATED	RAW	TREATED	
16	0.27	-	-	0.47	6.15	-	-	-	7.35	8.83	4.0
17	0.23	-	-	0.92	6.15	-	-	-	7.30	8.55	5.0
18	0.30	-	-	0.39	6.15	-	-	-	7.35	8.55	5.0
19	0.23	-	-	0.43	6.15	-	-	-	7.27	8.46	5.0
20	-	-	-	-	6.15	-	-	-	-	-	-
21	-	-	-	-	6.15	-	-	-	-	-	-
22	0.59	-	-	0.52	6.15	-	-	-	7.30	8.37	5.0
23	0.37	-	-	0.43	6.15	-	-	-	7.32	8.70	6.0
24	0.33	-	-	0.49	6.15	-	-	-	7.30	8.30	6.0
25	0.32	-	-	0.46	6.15	-	-	-	7.40	8.58	6.0
26	0.33	-	-	0.49	6.15	-	-	-	7.30	8.80	6.0
27	-	-	-	-	6.15	-	-	-	-	-	-
28	-	-	-	-	6.15	-	-	-	-	-	-
29	0.27	-	-	0.35	6.15	-	-	-	7.40	8.40	6.0
30	0.27	-	-	0.38	6.15	-	-	-	7.41	8.25	6.0

Total Fe Res for month 0.65 mg/L, Avg per day 0.32 mg/L

TABLE 2.1: PARTICULATE REMOVAL PROFILE (JULY/85)-LOCH LOMOND
MOE WPOS PROTOCOL

DATE	TURBIDITY (NTU)				SODIUM SILICATE	FILTER AID	METAL RES. (Al) (mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.	mg/L	mg/L	RAW	TREATED	RAW	TREATED	(C)
1	-	-	-	-	6.15	-	-	-	-	-	-
2	0.47	-	-	0.58	6.15	-	-	-	7.45	8.85	12.0
3	0.49	-	-	0.52	6.15	-	-	-	7.48	8.69	12.0
4	0.48	-	-	0.64	6.15	-	-	-	7.50	8.77	11.0
5	0.47	-	-	1.05	6.15	-	-	-	7.32	8.79	11.0
6	-	-	-	-	6.15	-	-	-	-	-	-
7	-	-	-	-	6.15	-	-	-	-	-	-
8	-	-	-	-	6.15	-	-	-	-	-	12.0
9	0.40	-	-	0.54	6.15	-	-	-	7.35	8.65	12.0
10	0.45	-	-	0.58	6.15	-	-	-	7.27	8.67	12.0
11	0.43	-	-	0.56	6.15	-	-	-	7.30	8.70	12.0
12	0.52	-	-	0.78	6.15	-	-	-	7.30	8.90	12.0
13	-	-	-	-	6.15	-	-	-	-	-	-
14	-	-	-	-	6.15	-	-	-	-	-	-
15	0.42	-	-	0.55	6.15	-	-	-	7.35	8.63	12.0

DATE	TURBIDITY (NTU)				SODIUM SILICATE mg/L	FILTER AID mg/L	METAL RES. (Al) (mg/L)		pH		TEMP (C)
	RAW	SET.	FILTER	TREAT.			RAW	TREATED	RAW	TREATED	
16	0.47	-	-	0.60	6.15	-	-	-	7.26	8.30	12.0
17	0.42	-	-	0.51	6.15	-	-	-	7.25	8.44	12.0
18	0.43	-	-	0.53	6.15	-	-	-	7.34	8.63	12.0
19	-	-	-	-	6.15	-	-	-	-	-	12.0
20	-	-	-	-	6.15	-	-	-	-	-	-
21	-	-	-	-	6.15	-	-	-	-	-	-
22	0.41	-	-	0.56	6.15	-	-	-	7.12	7.86	12.0
23	0.52	-	-	0.62	6.15	-	-	-	7.20	8.49	12.0
24	0.72	-	-	0.72	6.15	-	-	-	7.43	7.98	12.0
25	-	-	-	-	6.15	-	-	-	-	-	12.0
26	0.68	-	-	0.48	6.15	-	-	-	6.93	6.87	14.0
27	-	-	-	-	6.15	-	-	-	-	-	-
28	-	-	-	-	6.15	-	-	-	-	-	-
29	0.51	-	-	0.48	6.15	-	-	-	7.04	7.24	14.0
30	0.77	-	-	0.53	6.15	-	-	-	7.33	7.44	14.0
31	0.68	-	-	0.56	6.15	-	-	-	7.15	7.36	14.0

TABLE 2.1: PARTICULATE REMOVAL PROFILE (OCT/85)-LOCH LOMOND

MOE WPOS PROTOCOL

DATE	TURBIDITY (NTU)				SODIUM SILICATE mg/L	FILTER AID mg/L	METAL RES. (Al) (mg/L)		pH		TEMP (C)
	RAW	SET.	FILTER	TREAT.			RAW	TREATED	RAW	TREATED	
1	0.53	-	-	0.58	6.15	-	-	-	7.50	8.10	17.0
2	-	-	-	-	6.15	-	-	-	-	-	17.0
3	0.58	-	-	0.53	**	-	-	-	7.44	7.09	12.0
4	0.67	-	-	0.61	**	-	-	-	7.38	7.05	12.0
5	-	-	-	-	-	-			-	-	-
6	-	-	-	-	-	-	-	-	-	-	-
7	0.58	-	-	0.60	-	-	-	-	7.18	6.72	10.0
8	0.68	-	-	0.75	-	-	-	-	7.20	6.85	10.0
9	-	-	-	-	-	-	-	-	-	-	-
10	0.64	-	-	0.70	**	-	-	-	7.11	6.76	10.0
11	-	-	-	-	**	-	-	-	-	-	9.0
12	-	-	-	-	**	-			-	-	-
13	-	-	-	-	**	-	-	-	-	-	-
14	-	-	-	-	**	-	-	-	-	-	-
15	0.62	-	-	0.73	**	-	-	-	7.19	6.92	9.0

DATE	TURBIDITY (NTU)				SODIUM SILICATE mg/L	FILTER AID mg/L	METAL RES. (Al) (mg/L)		pH		TEMP (C)
	RAW	SET.	FILTER	TREAT.			RAW	TREATED	RAW	TREATED	
16	0.44	-	-	0.46	**	-	-	-	7.15	6.83	9.0
17	0.45	-	-	0.47	**	-	-	-	7.25	6.84	9.0
18	0.48	-	-	0.78	6.15	-	-	-	7.24	7.03	9.0
19	-	-	-	-	6.15	-	-	-	-	-	-
20	-	-	-	-	6.15	-			-	-	-
21	0.51	-	-	0.57	6.15	-	-	-	7.56	8.25	9.0
22	0.40	-	-	0.52	6.15	-	-	-	7.45	7.58	9.0
23	0.43	-	-	0.53	6.15	-	-	-	7.55	7.78	9.0
24	-	-	-	-	6.15	-	-	-	-	-	8.0
25	0.43	-	-	0.57	6.15	-	-	-	7.51	8.65	8.0
26	-	-	-	-	6.15	-	-	-	-	-	-
27	-	-	-	-	6.15	-			-	-	-
28	0.46	-	-	0.58	6.15	-	-	-	7.50	8.92	8.0
29	0.45	-	-	0.53	6.15	-	-	-	7.45	8.10	8.0
30	0.46	-	-	0.56	6.15	-	-	-	7.45	8.92	7.0
31	0.44	-	-	0.61	6.15	-	-	-	7.43	8.72	7.0

* Fe Res - Avg per day 0.05 mg/L-Total for month 0.15 mg/L
SODIUM SILICATE USED AS COAGULANT

** Out of service.

TABLE 2.1: PARTICULATE REMOVAL PROFILE (JAN/86)-LOCH LOMOND
MOE WPOS PROTOCOL

DATE	TURBIDITY (NTU)				SODIUM SILICATE mg/L	FILTER AID mg/L	METAL RES. (Al) (mg/L)		pH		TEMP (C)
	RAW	SET.	FILTER	TREAT.			RAW	TREATED	RAW	TREATED	
1	-	-	-	-	6.15	-	-	-	-	-	-
2	0.42	-	-	0.53	6.15	-	-	-	7.28	7.89	2
3	0.28	-	-	0.42	6.15	-	-	-	7.10	7.70	2
4	-	-	-	-	6.15	-	-	-	-	-	-
5	-	-	-	-	6.15	-	-	-	-	-	-
6	0.29	-	-	0.38	6.15	-	-	-	7.11	7.54	2
7	0.33	-	-	0.43	6.15	-	-	-	7.16	7.80	2
8	0.31	-	-	0.41	6.15	-	-	-	7.13	7.47	2
9	0.27	-	-	0.36	6.15	-	-	-	7.04	7.28	2
10	0.32	-	-	0.38	6.15	-	-	-	7.10	7.42	2
11	-	-	-	-	6.15	-	-	-	-	-	-
12	-	-	-	-	6.15	-	-	-	-	-	-
13	-	-	-	-	6.15	-	-	-	-	-	2
14	-	-	-	-	6.15	-	-	-	-	-	2
15	0.32	-	-	0.41	6.15	-	-	-	7.14	7.70	2

TABLE 2.1 (cont'd)

DATE	TURBIDITY (NTU)				SODIUM SILICATE mg/L	FILTER AID mg/L	METAL RES. (Al) (mg/L)		pH		TEMP (C)
	RAW	SET.	FILTER	TREAT.			RAW	TREATED	RAW	TREATED	
16	0.52	-	-	0.35	6.15	-	-	-	7.09	7.65	2
17	0.27	-	-	0.38	6.15	-	-	-	7.07	7.50	2
18	-	-	-	-	6.15	-	-	-	-	-	-
19	-	-	-	-	6.15	-	-	-	-	-	-
20	0.32	-	-	0.40	6.15	-	-	-	7.30	9.50	2
21	0.33	-	-	0.38	6.15	-	-	-	7.70	9.70	2
22	0.31	-	-	0.39	6.15	-	-	-	7.15	9.60	2
23	0.32	-	-	0.42	6.15	-	-	-	7.09	9.60	2
24	0.34	-	-	0.41	6.15	-	-	-	7.23	9.40	2
25	-	-	-	-	6.15	-	-	-	-	-	-
26	-	-	-	-	6.15	-	-	-	-	-	-
27	0.24	-	-	0.39	6.15	-	-	-	7.16	9.60	2
28	0.28	-	-	0.41	6.15	-	-	-	7.01	9.80	2
29	0.23	-	-	0.30	6.15	-	-	-	7.12	9.70	2
30	0.35	-	-	0.47	6.15	-	-	-	7.03	9.70	2
31	0.23	-	-	0.33	6.15	-	-	-	7.14	10.00	2

* Total Fe Res for month 0.10 mg/L, Avg per day 0.05 mg/L

TABLE 2.1: PARTICULATE REMOVAL PROFILE (APRIL/86) LOCH LOMOND
MOE WPOS PROTOCOL

DATE	TURBIDITY (NTU)				SODIUM SILICATE mg/L	FILTER AID mg/L	METAL RES. (Al) (mg/L)		pH		TEMP (C)
	RAW	SET.	FILTER	TREAT.			RAW	TREATED	RAW	TREATED	
1	0.30	-	-	0.32	6.15	-	-	-	9.50	9.50	2
2	0.30	-	-	-	6.15	-	-	-	9:90	9.50	2
3	0.30	-	-	0.37	6.15	-	-	-	9.70	9.70	2
4	0.30	-	-	0.36	6.15	-	-	-	9.60	9.70	2
5	-	-	-	-	6.15	-	-	-	-	-	-
6	-	-	-	-	6.15	-	-	-	-	-	-
7	0.30	-	-	0.36	6.15	-	-	-	9.70	9.80	2
8	0.30	-	-	0.46	6.15	-	-	-	9.80	9.70	3
9	0.30	-	-	0.41	6.15	-	-	-	7.00	9.70	3
10	0.33	-	-	0.40	6.15	-	-	-	7.00	9.60	3
11	0.51	-	-	0.39	6.15	-	-	-	7.05	9.70	3
12	-	-	-	-	6.15	-	-	-	-	-	-
13	-	-	-	-	6.15	-	-	-	-	-	-
14	0.50	-	-	0.82	6.15	-	-	-	9.50	9.50	3
15	0.50	-	-	0.58	6.15	-	-	-	9.40	9.40	3

DATE	TURBIDITY (NTU)				SODIUM SILICATE	FILTER AID	METAL RES. (Al) (mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.	mg/L	mg/L	RAW	TREATED	RAW	TREATED	(C)
16	0.52	-	-	0.58	6.15	-	-	-	9.60	9.60	3
17	0.40	-	-	0.43	6.15	-	-	-	9.30	9.30	3
18	0.45	-	-	0.43	6.15	-	-	-	9.30	9.30	3
19	-	-	-	-	6.15	-	-	-	-	-	-
20	-	-	-	-	6.15	-	-	-	-	-	-
21	0.30	-	-	0.44	6.15	-	-	-	7.00	9.40	3
22	0.33	-	-	0.44	6.15	-	-	-	6.97	9.60	3
23	0.32	-	-	0.43	6.15	-	-	-	7.03	9.40	3
24	0.31	-	-	0.43	6.15	-	-	-	7.04	9.50	3
25	0.60	-	-	0.58	6.15	-	-	-	6.96	9.50	4
26	-	-	-	-	6.15	-	-	-	-	-	-
27	-	-	-	-	6.15	-	-	-	-	-	-
28	0.40	-	-	0.48	6.15	-	-	-	7.05	9.70	4
29	0.40	-	-	0.48	6.15	-	-	-	6.87	9.90	4
30	0.40	-	-	0.55	6.15	-	-	-	6.49	9.80	4

* Total Fe Res for month <0.01 mg/L, Avg per day <0.05 mg/L

TABLE 2.1: PARTICULATE REMOVAL PROFILE (JULY/86)-LOCH LOMOND
MOE WPOS PROTOCOL

DATE	TURBIDITY (NTU) RAW	TURBIDITY (NTU) SET.	TURBIDITY (NTU) FILTER	TURBIDITY (NTU) TREAT.	SODIUM SILICATE mg/L	FILTER AID mg/L	METAL RES. (Al) (mg/L) RAW	METAL RES. (Al) (mg/L) TREATED	pH RAW	pH TREATED	TEMP (C)
1	-	-	-	-	6.15	-	-	-	-	N/A	N/A
2	0.85	-	-	0.54	6.15	-	-	-	7.21	9.40	10
3	0.60	-	-	0.62	6.15	-	-	-	7.11	9.40	10
4	0.40	-	-	0.82	6.15	-	-	-	7.34	9.40	10
5	-	-	-	-	6.15	-	-	-	-	-	-
6	-	-	-	-	6.15	-	-	-	-	-	-
7	0.48	-	-	1.20	6.15	-	-	-	7.20	9.40	10
8	0.48	-	-	0.42	6.15	-	-	-	7.20	9.40	10
9	0.49	-	-	0.77	6.15	-	-	-	7.20	9.40	10
10	0.48	-	-	0.58	6.15	-	-	-	7.26	9.20	11
11	0.46	-	-	0.67	6.15	-	-	-	7.24	9.40	11
12	-	-	-	-	6.15	-	-	-	-	-	-
13	-	-	-	-	6.15	-	-	-	-	-	-
14	0.60	-	-	0.88	6.15	-	-	-		9.60	12
15	0.48	-	-	0.58	6.15	-	-	-	7.26	8.70	12

DATE	TURBIDITY (NTU) RAW	SET.	FILTER	TREAT.	SODIUM SILICATE mg/L	FILTER AID mg/L	METAL RES. (Al) (mg/L) RAW	TREATED	pH RAW	pH TREATED	TEMP (C)
16	0.45	-	-	-	6.15	-	-	-	-	9.20	12
17	0.47	-	-	0.66	6.15	-	-	-	7.28	8.90	11
18	0.48	-	-	0.81	6.15	-	-	-	7.31	-	11
19	-	-	-	-	**	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-
21	0.45	-	-	-	-	-	-	-	-	5.80	12
22	0.45	-	-	0.48	-	-	-	-	7.00	5.90	12
23	0.43	-	-	0.78	-	-	-	-	7.07	5.90	12
24	0.45	-	-	0.53	-	-	-	-	7.10	5.90	12
25	0.43	-	-	0.50	-	-	-	-	7.02	5.90	12
26	-	-	-	-	-	-	-	-	-	-	-
27	-	-	-	-	-	-	0.005	-	-	-	-
28	0.55	-	-	0.67	-	-	-	-	6.94	5.90	12
29	0.60	-	-	-	-	-	-	-	-	8.40	12
30	0.60	-	-	0.53	-	-	-	-	7.13	8.20	12
31	0.55	-	-	0.53	-	-	-	-	7.12	8.40	12

* Fe Res - Avg per day 0.68 mg/L. Total for month 2.05 mg/L

** INOPERATIVE AS OF 3:10 JULY 18TH

TABLE 2.1: PARTICULATE REMOVAL PROFILE (OCT/86)-LOCH LOMOND

MOE WPOS PROTOCOL

DATE	TURBIDITY (NTU)				SODIUM SILICATE	FILTER AID	METAL RES. (Al) (mg/L)		pH		TEMP
	RAW	SET.	FILTER	TREAT.	mg/L	mg/L	RAW	TREATED	RAW	TREATED	(C)
1	0.53	-	-	0.49	15.75	-	-	-	7.39	9.3	10
2	0.53	-	-	0.70	18.10	-	-	-	7.52	9.30	11
3	0.50	-	-	0.51	16.39	-	-	-	7.44	9.20	11
4	-	-	-	-	16.39	-	-	-	-	-	-
5	-	-	-	-	16.39	-	0.005	0.008	-	-	-
6	0.53	-	-	0.48	16.37	-	-	-	7.33	9.40	10
7	0.52	-	-	0.48	18.14	-	-	-	7.35	9.40	10
8	0.53	-	-	0.57	15.53	-	-	-	7.38	9.40	10
9	0.53	-	-	-	16.93	-	-	-	-	9.20	10
10	0.52	-	-	0.44	17.41	-	-	-	7.26	9.10	10
11	-	-	-	-	17.41	-	-	-	-	-	-
12	-	-	-	-	-	-	0.003	0.005	-	-	-
13	-	-	-	-	17.41	-	-	-	-	-	-
14	0.52	-	-	0.52	16.73	-	-	-	7.32	9.00	9
15	0.53	-	-	0.53	16.44	-	-	-	7.43	9.00	9

DATE	TURBIDITY (NTU)				SODIUM SILICATE mg/L	FILTER AID mg/L	METAL RES. (Al) (mg/L)		pH		TEMP (C)
	RAW	SET.	FILTER	TREAT.			RAW	TREATED	RAW	TREATED	
16	0.53	-	-	0.53	15.67	-	-	-	7.38	9.00	8
17	0.52	-	-	0.52	17.33	-	-	-	7.33	9.00	8
18	-	-	-	-	17.33	-	-	-	-	-	-
19	-	-	-	-	17.33	-	0.003	0.007	-	-	-
20	0.50	-	-	0.52	13.74	-	-	-	7.34	8.80	8
21	0.57	-	-	0.51	17.90	-	-	-	7.40	8.90	7
22	0.52	-	-	0.37	14.77	-	-	-	7.40	7.80	7
23	0.50	-	-	0.47	15.81	-	-	-	7.45	8.70	8
24	0.48	-	-	0.48	16.16	-	-	-	7.40	8.80	8
25	-	-	-	-	16.16	-	-	-	-	-	-
26	-	-	-	-	16.16	-	0.008	0.008	-	-	-
27	0.48	-	-	0.49	16.88	-	-	-	7.40	9.00	8
28	0.50	-	-	0.48	12.13	-	-	-	7.46	8.80	8
29	0.50	-	-	0.56	14.10	-	-	-	7.38	8.70	8
30	0.51	-	-	0.43	14.78	-	-	-	7.30	9.40	8
31	0.52	-	-	0.57	14.53	-	-	-	7.32	9.30	8

*   Fe Res - Avg per day 0.05 mg/L-Total for month 0.15 mg/L

TABLE 3

WATER PLANT OPTIMIZATION STUDY
"DISINFECTION SUMMARY"

TABLE 3.0: DISINFECTION SUMMARY LOCH LOMOND

MOE WPOS PROTOCOL

		1986			1985			1984		
		CHLORINATION			CHLORINATION			CHLORINATION		
		MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG
JAN	Cl2 Demand	2.18	1.47	1.73	2.27	1.68	1.94	2.26	1.1	1.51
	Cl2 Dosage	4.29	3.64	3.85	3.87	3.3	3.63	4.27	3.01	3.36
	Ammonia									
	SO2									
	Residual Cl2 Free									
	Before the Reservoir	2.85	2.14	2.35	2.81	2.02	2.49	3.08	1.7	2.31
	Exiting the Reservoir	2.19	1.92	2.04	1.94	1.44	1.67	2.59	1.42	1.82
FEB	Cl2 Demand	2.4	1.16	1.68	2.26	1.7	1.91	1.67	1.36	1.49
	Cl2 Dosage	4.07	3.29	3.6	3.77	3.42	3.63	3.57	2.97	3.35
	Ammonia									
	SO2									
	Residual Cl2 Free									
	Before the Reservoir	2.69	1.91	2.28	2.61	2.21	2.42	2.62	1.9	2.21
	Exiting the Reservoir	2.34	1.4	1.94	1.91	1.4	1.78	2.07	1.6	1.83
MAR	Cl2 Demand	1.88	1.49	1.63	2.39	1.7	1.9	1.96	1.5	1.63
	Cl2 Dosage	3.73	3.33	3.5	4.25	3.51	3.81	3.63	3.25	3.39
	Ammonia									
	SO2									
	Residual Cl2 Free									
	Before the Reservoir	2.52	1.9	2.19	2.97	2.38	2.54	2.89	1.94	2.27
	Exiting the Reservoir	2.07	1.67	1.9	2.12	1.78	1.9	1.92	1.35	1.74
APR	Cl2 Demand	2.33	1.39	1.82	2.33	1.47	2.01	1.99	0.98	1.65
	Cl2 Dosage	4.06	3.54	3.76	4.31	3.58	4.01	3.54	3.23	3.26
	Ammonia									
	SO2									
	Residual Cl2 Free									
	Before the Reservoir	2.82	1.87	2.16	3.02	2.04	2.56	2.64	1.99	2.22
	Exiting the Reservoir	2.26	1.58	1.96	2.21	1.8	1.88	2.49	1.48	1.75

MOE WPOS PROTOCOL

		1986			1985			1984		
		CHLORINATION			CHLORINATION			CHLORINATION		
		MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG
MAY	Cl2 Demand	3.34	1.54	2.02	2.07	1.45	1.77	1.98	0.94	1.72
	Cl2 Dosage	4.93	3.34	3.89	3.99	3.66	3.8	3.82	3.29	3.44
	Ammonia									
	SO2									
	Residual Cl2 Free									
	Before the Reservoir	3.1	1.8	2.18	2.68	2.05	2.38	2.62	2.04	2.33
	Exiting the Reservoir	2.75	1.28	1.93	2.26	1.81	2.04	2.27	1.38	1.71
JUN	Cl2 Demand	2.74	1.59	2.1	2.15	1.53	1.99	1.99	1.01	1.72
	Cl2 Dosage	4.74	3.53	4.07	4.28	3.71	4.01	3.99	3.21	3.65
	Ammonia									
	SO2									
	Residual Cl2 Free									
	Before the Reservoir	2.7	1.75	2.32	2.69	2.12	2.38	2.95	2	2.42
	Exiting the Reservoir	2.35	1.56	1.87	2.2	1.94	2.05	2.2	1.62	1.78
JUL	Cl2 Demand	2.58	1.14	1.81	2.24	1.56	1.94	N/A	N/A	N/A
	Cl2 Dosage	4.64	3.24	3.98	4.23	3.8	4.01	4.17	3.71	3.95
	Ammonia									
	SO2									
	Residual Cl2 Free									
	Before the Reservoir	2.72	2.1	2.35	2.55	2.04	2.37	2.57	2	2.41
	Exiting the Reservoir	2.54	1.98	2.14	2.24	1.86	2.02	N/A	N/A	N/A
AUG	Cl2 Demand	2.48	1.37	1.96	2.61	1.75	2.1	2.44	1.39	1.9
	Cl2 Dosage	4.34	3.69	4.01	4.68	3.64	4.16	4.19	3.55	3.92
	Ammonia									
	SO2									
	Residual Cl2 Free									
	Before the Reservoir	2.6	2.06	2.29	3.08	2.33	2.67	3.38	2.44	3.17
	Exiting the Reservoir	2.41	1.45	2.02	2.56	1.83	2.23	2.37	1.52	2.14

MOE WPOS PROTOCOL

		1986			1985			1984		
		CHLORINATION			CHLORINATION			CHLORINATION		
		MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG
SEP	Cl2 Demand	2.93	1.84	2.2	3.11	1.49	2.15	2.76	1.88	2.3
	Cl2 Dosage	4.98	3.83	4.3	5.29	4.17	4.56	4.55	4.02	4.29
	Ammonia									
	SO2									
	Residual Cl2 Free									
	Before the Reservoir	2.76	2.08	2.29	3.38	2.4	2.83	3.4	2.53	3.08
	Exiting the Reservoir	2.25	1.84	2.09	2.99	1.74	2.45	2.44	1.65	1.99
OCT	Cl2 Demand	2.43	1.8	2.16	2.71	1	1.79	2.76	1.81	2.02
	Cl2 Dosage	4.78	3.63	4.38	4.99	3.2	4.21	4.79	3.46	4.1
	Ammonia									
	SO2									
	Residual Cl2 Free									
	Before the Reservoir	2.84	2.01	2.38	3.29	1.91	2.6	2.95	2.45	2.71
	Exiting the Reservoir	2.6	1.8	2.22	3.08	1.75	2.51	2.21	1.62	1.99
NOV	Cl2 Demand	2.24	1.47	1.89	1.82	1.17	1.54	2.36	1.53	1.91
	Cl2 Dosage	4.24	3.39	3.76	3.79	3.39	3.53	4.27	3.63	3.93
	Ammonia									
	SO2									
	Residual Cl2 Free									
	Before the Reservoir	2.65	1.75	2.05	2.47	2.05	2.3	2.99	2.18	2.6
	Exiting the Reservoir	2.19	1.39	1.87	2.28	1.77	2	2.5	1.45	1.97
DEC	Cl2 Demand	2.2	1.55	1.79	2.08	1.34	1.72	2.22	1.38	1.89
	Cl2 Dosage	3.9	3.38	3.66	4.29	3.5	3.95	4.09	3.25	3.77
	Ammonia									
	SO2									
	Residual Cl2 Free									
	Before the Reservoir	2.45	1.6	1.91	2.74	2.24	2.45	2.95	2.47	2.49
	Exiting the Reservoir	2.08	1.48	1.83	2.41	1.95	2.19	2.5	1.45	1.91

TABLE 3.2: DISINFECTION PROFILE (JAN/1984)-LOCH LOMOND

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION* Cl2 Dem.	Cl2 Dos.***	NH3	SO2	RESIDUAL Cl2 Free	RESIDUAL Cl2 Comb	RESIDUAL Cl2 Total	POST-CHLORINATION** Cl2 Dem.	Cl2 Dos.	NH3	SO2	RESIDUAL Cl2 Free	RESIDUAL Cl2 Comb	RESIDUAL Cl2 Total
1		3.62			N/A							N/A		
2		3.62			N/A							N/A		
3		4.27			2.01							2.65		
4		3.50			2.40							3.08		
5		3.36			1.97							2.29		
6		3.26			1.60							2.20		
7		3.26			N/A							N/A		
8		3.26			N/A							N/A		
9		3.20			2.21							1.73		
10		3.45			2.28							1.78		
11		3.47			2.59							2.01		
12		3.27			2.28							1.92		
13		3.42			2.35							1.92		
14		3.42			N/A							N/A		
15		3.42			N/A							N/A		

* Free Residual measured 12 m d/s from point of injection

** Free Residual measured immediately d/s of reservoir

*** Constitutes total chlorine dosage applied for pre and post-chlorination

TABLE 3.2 (cont'd)

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION*							POST-CHLORINATION**						
	Cl2		NH3	SO2	RESIDUAL Cl2			Cl2		NH3	SO2	RESIDUAL Cl2		
	Dem.	Dos.***			Free	Comb	Total	Dem.	Dos.			Free	Comb	Total
16		3.48			2.22							1.70		
17		3.40			2.30							1.89		
18		3.32			2.35							1.71		
19		3.46			2.06							1.71		
20		3.34			1.65							1.90		
21		3.34			N/A							N/A		
22		3.34			N/A							N/A		
23		3.37			1.81							2.07		
24		3.58			1.65							2.10		
25		3.25			1.55							1.98		
26		3.25			1.42							2.51		
27		3.23			1.71							2.25		
28		3.23			N/A							N/A		
29		3.23			N/A							N/A		
30		3.34			1.81							2.32		
31		3.01			1.87							2.45		

TABLE 3.2: DISINFECTION PROFILE (APRIL/1984)-LOCH LOMOND
MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION*							POST-CHLORINATION**						
	Cl2		NH3	SO2	RESIDUAL Cl2			Cl2		NH3	SO2	RESIDUAL Cl2		
	Dem.	Dos.***			Free	Comb	Total	Dem.	Dos.			Free	Comb	Total
1		3.47			N/A							N/A		
2		3.47			2.49							2.64		
3		3.50			1.97							2.44		
4		3.47			1.48							2.29		
5		3.45			1.87							2.54		
6		3.37			1.96							2.41		
7		3.37			N/A							N/A		
8		3.37			N/A							N/A		
9		3.42			1.87							2.42		
10		3.54			1.53							2.22		
11		3.49			1.67							2.11		
12		3.40			1.58							2.14		
13		3.42			1.58							1.96		
14		3.42			N/A							N/A		
15		3.42			N/A							N/A		

* Free Residual measured 12 m d/s from point of injection
** Free Residual measured immediately d/s of reservoir
*** Constitutes total chlorine dosage applied for pre and post-chlorination

TABLE 3.2 (cont'd)

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION* Cl2 Dem.	PRE-CHLORINATION* Cl2 Dos.***	NH3	SO2	RESIDUAL Cl2 Free	RESIDUAL Cl2 Comb	RESIDUAL Cl2 Total	POST-CHLORINATION** Cl2 Dem.	POST-CHLORINATION** Cl2 Dos.	NH3	SO2	RESIDUAL Cl2 Free	RESIDUAL Cl2 Comb	RESIDUAL Cl2 Total
16		3.45			1.64							2.21		
17		3.53			1.65							2.16		
18		3.40			1.90							2.19		
19		3.25			1.51							2.11		
20		3.25			N/A							N/A		
21		3.25			N/A							N/A		
22		3.25			N/A							N/A		
23		3.25			N/A							N/A		
24		3.32			1.82							2.36		
25		3.29			1.78							2.21		
26		3.24			1.54							1.99		
27		3.27			1.59							2.39		
28		3.27			N/A							N/A		
29		3.27			N/A							N/A		
30		3.23			1.81							2.04		

TABLE 3.2: DISINFECTION PROFILE (JULY/1984)-LOCH LOMOND

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION*							POST-CHLORINATION**						
	Cl2		NH3	SO2	RESIDUAL Cl2			Cl2		NH3	SO2	RESIDUAL Cl2		
	Dem.	Dos.***			Free	Comb	Total	Dem.	Dos.			Free	Comb	Total
1		3.87			2.30							N/A		
2		3.95			2.20							N/A		
3		3.94			2.10							2.65		
4		3.94			2.00							3.08		
5		3.94			2.00							2.29		
6		3.76			2.10							2.20		
7		3.76			2.20							N/A		
8		3.76			2.50							N/A		
9		3.83			2.50							1.73		
10		3.93			2.50							1.78		
11		3.93			2.50							2.01		
12		4.13			2.50							1.92		
13		4.13			2.50							1.92		
14		4.13			2.50							N/A		
15		4.12			2.50							N/A		

* Free Residual measured 12 m d/s from point of injection

** Free Residual measured immediately d/s of reservoir

*** Constitutes total chlorine dosag

TABLE 3.2 (cont'd)

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION*							POST-CHLORINATION**						
	Cl2		NH3	SO2	RESIDUAL Cl2			Cl2		NH3	SO2	RESIDUAL Cl2		
	Dem.	Dos.***			Free	Comb	Total	Dem.	Dos.			Free	Comb	Total
16		4.12			2.50									
17		4.12			2.50									
18		4.12			2.50									
19		4.17			2.50									
20		4.17			2.50									
21		4.17			2.50									
22		4.01			N/A									
23		4.01			N/A									
24		3.89			2.42									
25		3.84			2.33									
26		3.77			2.40									
27		3.92			2.43									
28		3.92			2.48									
29		3.92			2.48									
30		3.92			2.48									
31		3.71			2.57									

TABLE 3.2: DISINFECTION PROFILE (OCT/1984)-LOCH LOMOND
MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION* Cl2 Dem.	Cl2 Dos.***	NH3	SO2	RESIDUAL Cl2 Free	RESIDUAL Cl2 Comb	RESIDUAL Cl2 Total	POST-CHLORINATION** Cl2 Dem.	Cl2 Dos.	NH3	SO2	RESIDUAL Cl2 Free	RESIDUAL Cl2 Comb	RESIDUAL Cl2 Total
1		4.14			1.72							2.73		
2		4.09			2.21							2.87		
3		4.79			2.03							2.67		
4		3.46			1.62							2.76		
5		4.05			2.09							2.81		
6		4.05			N/A							N/A		
7		4.05			N/A							N/A		
8		4.05			N/A							N/A		
9		3.90			2.95							1.78		
10		4.03			2.72							1.78		
11		4.32			2.59							2.05		
12		4.15			2.59							1.65		
13		4.15			N/A							N/A		
14		4.15			N/A							N/A		
15		4.18			2.11							2.82		

* Free Residual measured 12 m d/s from point of injection
** Free Residual measured immediately d/s of reservoir
*** Constitutes total chlorine dosage applied for pre and post-chlorination

TABLE 3.2 (cont'd)

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION*							POST-CHLORINATION**						
	Cl2		NH3	SO2	RESIDUAL Cl2			Cl2		NH3	SO2	RESIDUAL Cl2		
	Dem.	Dos.***			Free	Comb	Total	Dem.	Dos.			Free	Comb	Total
16		4.14			1.77							2.66		
17		4.23			2.02							2.60		
18		3.89			1.98							2.79		
19		4.29			2.21							2.72		
20		4.29			N/A							N/A		
21		4.29			N/A							N/A		
22		3.98			2.52							2.05		
23		4.19			2.81							2.13		
24		4.00			2.83							2.13		
25		3.98			2.57							1.99		
26		4.09			2.58							1.84		
27		4.09			N/A							N/A		
28		4.09			N/A							N/A		
29		4.17			2.92							1.96		
30		3.80			2.85							1.99		
31		4.00			2.45							2.50		

TABLE 3.2: DISINFECTION PROFILE (JAN/1985)-LOCH LOMOND
MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION* Cl2 Dem.	Cl2 Dos.***	NH3	SO2	RESIDUAL Cl2 Free	Comb	Total	POST-CHLORINATION** Cl2 Dem.	Cl2 Dos.	NH3	SO2	RESIDUAL Cl2 Free	Comb	Total
1		3.30			N/A							N/A		
2		3.56			1.45							2.57		
3		3.67			1.55							2.43		
4		3.71			1.44							2.40		
5		3.71			N/A							N/A		
6		3.71			N/A							N/A		
7		3.76			2.79							1.61		
8		3.57			2.68							1.48		
9		3.70			2.70							1.45		
10		3.50			2.68							1.71		
11		3.73			2.46							1.86		
12		3.73			N/A							N/A		
13		3.73			N/A							N/A		
14		3.65			1.74							2.71		
15		3.65			1.61							2.63		

* Free Residual measured 12 m d/s from point of injection

** Free Residual measured immediately d/s of reservoir

*** Constitutes total chlorine dosage applied for pre and post-chlorination

TABLE 3.2 (cont'd)

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION* Cl2 Dem.	Cl2 Dos.***	NH3	SO2	RESIDUAL Cl2 Free	Comb	Total	POST-CHLORINATION** Cl2 Dem.	Cl2 Dos.	NH3	SO2	RESIDUAL Cl2 Free	Comb	Total
16		3.62			1.94							2.53		
17		3.67			1.59							2.42		
18		3.67			1.89							2.61		
19		3.69			N/A							N/A		
20		3.67			N/A							N/A		
21		3.58			2.66							1.75		
22		3.41			2.81							1.89		
23		3.87			2.02							1.73		
24		3.54			2.42							1.77		
25		3.63			2.22							1.79		
26		3.63			N/A							N/A		
27		3.63			N/A							N/A		
28		3.65			1.61							2.44		
29		3.69			1.72							2.19		
30		3.54			1.69							2.54		
31		3.49			1.77							2.12		

TABLE 3.2: OISINFECTION PROFILE (APRIL/1985)-LOCH LOMOND
MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION*							POST-CHLORINATION**						
	Cl_2		NH3	SO2	RESIDUAL Cl_2			Cl_2		NH3	SO2	RESIDUAL Cl_2		
	Dem.	Dos.***			Free	Comb	Total	Dem.	Dos.			Free	Comb	Total
1		4.31			2.85							1.99		
2		4.07			2.67							2.04		
3		3.79			2.60							2.00		
4		4.18			2.59							2.02		
5		4.18			N/A							N/A		
6		4.18			N/A							N/A		
7		4.18			N/A							N/A		
8		4.18			N/A							N/A		
9		4.14			2.70							1.86		
10		4.12			2.67							1.91		
11		4.03			2.65							1.96		
12		4.11			2.66							1.91		
13		4.11			N/A							N/A		
14		4.11			N/A							N/A		
15		4.15			1.82							2.68		

* Free Residual measured 12 m d/s from point of injection
** Free Residual measured immediately d/s of reservoir
*** Constitutes total chlorine dosage applied for pre and post-chlorination

TABLE 3.2 (cont'd)

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION*							POST-CHLORINATION**						
	Cl2		NH3	SO2	RESIDUAL Cl2			Cl2		NH3	SO2	RESIDUAL Cl2		
	Dem.	Dos.***			Free	Comb	Total	Dem.	Dos.			Free	Comb	Total
16		3.76			1.85							2.69		
17		3.93			2.21							2.73		
18		3.70			2.21							3.02		
19		3.99			1.80							2.52		
20		3.99			N/A							N/A		
21		3.99			N/A							N/A		
22		3.77			1.84							2.50		
23		4.06			2.02							2.19		
24		3.97			2.08							2.40		
25		3.78			2.02							2.40		
26		3.85			2.02							2.42		
27		3.85			N/A							N/A		
28		3.85			N/A							N/A		
29		3.58			2.11							2.59		
30		4.26			1.86							2.04		

TABLE 3.2: DISINFECTION PROFILE (JULY/1985)-LOCH LOMOND

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION* Cl2 Dem.	Cl2 Dos.***	NH3	SO2	RESIDUAL Cl2 Free	Comb	Total	POST-CHLORINATION** Cl2 Dem.	Cl2 Dos.	NH3	SO2	RESIDUAL Cl2 Free	Comb	Total
1		4.17			N/A							N/A		
2		4.12			2.06							2.15		
3		3.82			2.13							2.50		
4		4.06			1.98							2.16		
5		4.10			1.86							2.04		
6		4.10			N/A							N/A		
7		4.10			N/A							N/A		
8		4.10			N/A							N/A		
9		4.04			1.75							2.20		
10		3.90			2.00							2.30		
11		3.95			2.10							2.40		
12		3.95			N/A							N/A		
13		3.95			N/A							N/A		
14		3.95			N/A							N/A		
15		3.99			2.06							2.44		

* Free Residual measured 12 m d/s from point of injection

** Free Residual measured immediately d/s of reservoir

*** Constitutes total chlorine dosage applied for pre and post-chlorination

TABLE 3.2 (cont'd)

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION* Cl2 Dem.	PRE-CHLORINATION* Cl2 Dos.***	NH3	SO2	RESIDUAL Cl2 Free	RESIDUAL Cl2 Comb	RESIDUAL Cl2 Total	POST-CHLORINATION** Cl2 Dem.	POST-CHLORINATION** Cl2 Dos.	NH3	SO2	RESIDUAL Cl2 Free	RESIDUAL Cl2 Comb	RESIDUAL Cl2 Total
16		4.01			2.00							2.45		
17		4.23			2.05							2.45		
18		4.21			2.10							2.52		
19		4.07			2.50							2.00		
20		4.07			N/A							N/A		
21		4.07			N/A							N/A		
22		4.02			2.00							2.50		
23		3.99			2.00							2.55		
24		3.99			2.05							2.55		
25		4.07			2.17							2.44		
26		3.80			2.24							2.44		
27		3.80			N/A							N/A		
28		3.80			N/A							N/A		
29		3.85			N/A							N/A		
30		3.98			N/A							N/A		
31		3.94			N/A							N/A		

TABLE 3.2: DISINFECTION PROFILE (OCT/1985)-LOCH LOMOND

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION*							POST-CHLORINATION**						
	Cl2		NH3	SO2	RESIDUAL Cl2			Cl2		NH3	SO2	RESIDUAL Cl2		
	Dem.	Dos.***			Free	Comb	Total	Dem.	Dos.			Free	Comb	Total
1		3.89			2.15							2.64		
2		3.79			2.01							2.02		
3		4.17			2.15							2.12		
4		3.20			2.20							2.20		
5		3.20			N/A							N/A		
6		3.20			N/A							N/A		
7		4.21			2.50							2.63		
8		4.12			2.70							2.93		
9		4.02			N/A							N/A		
10		4.42			3.08							3.29		
11		4.82			2.65							2.82		
12		4.82			N/A							N/A		
13		4.82			N/A							N/A		
14		4.82			N/A							N/A		
15		4.84			2.13							N/A		

* Free Residual measured 12 m d/s from point of injection

** Free Residual measured immediately d/s of reservoir

*** Constitutes total chlorine dosage applied for pre and post-chlorination

TABLE 3.2 (cont'd)

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION*							POST-CHLORINATION**						
	Cl2		NH3	SO2	RESIDUAL Cl2			Cl2		NH3	SO2	RESIDUAL Cl2		
	Dem.	Dos.***			Free	Comb	Total	Dem.	Dos.			Free	Comb	Total
16		4.67			3.60							N/A		
17		4.79			2.75							N/A		
18		4.49			2.90							N/A		
19		4.49			N/A							N/A		
20		4.49			N/A							N/A		
21		4.69			2.60							2.82		
22		4.80			2.79							2.81		
23		4.99			2.96							3.12		
24		4.73			2.78							3.13		
25		4.38			2.73							3.06		
26		4.38			N/A							N/A		
27		4.38			N/A							N/A		
28		4.16			2.39							2.82		
29		3.54			1.75							1.91		
30		3.42			2.01							2.12		
31		3.67			1.90							2.26		

TABLE 3.2: DISINFECTION PROFILE (JAN/1986)-LOCH LOMOND

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION*							POST-CHLORINATION**						
	Cl2		NH3	SO2	RESIDUAL Cl2			Cl2		NH3	SO2	RESIDUAL Cl2		
	Dem.	Dos.***			Free	Comb	Total	Dem.	Dos.			Free	Comb	Total
1		4.29			N/A							N/A		
2		4.04			2.16							2.51		
3		4.01			1.85							2.51		
4		4.01			N/A							N/A		
5		4.01			N/A							N/A		
6		4.09			2.16							2.29		
7		4.10			1.92							2.43		
8		3.66			1.97							2.21		
9		3.64			2.19							2.85		
10		3.71			1.95							2.28		
11		3.71			N/A							N/A		
12		3.71			N/A							N/A		
13		3.76			2.25							2.02		
14		3.86			2.28							1.99		
15		3.67			2.34							2.02		

* Free Residual measured 12 m d/s from point of injection

** Free Residual measured immediately d/s of reservoir

*** Constitutes total chlorine dosage applied for pre and post-chlorination

TABLE 3.2 (cont'd)

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION*							POST-CHLORINATION**						
	Cl2		NH3	SO2	RESIDUAL Cl2			Cl2		NH3	SO2	RESIDUAL Cl2		
	Dem.	Dos.***			Free	Comb	Total	Dem.	Dos.			Free	Comb	Total
16		3.74			2.38							2.01		
17		3.66			2.14							2.05		
18		3.66			N/A							N/A		
19		3.66			N/A							N/A		
20		3.68			2.35							1.95		
21		3.85			2.30							2.10		
22		3.67			2.15							2.01		
23		3.69			2.25							2.09		
24		3.75			2.39							2.12		
25		3.75			N/A							N/A		
26		N/A			N/A							N/A		
27		N/A			N/A							N/A		
28		N/A			N/A							N/A		
29		N/A			N/A							N/A		
30		N/A			N/A							N/A		

TABLE 3.2: DISINFECTION PROFILE (APRIL/1986)-LOCH LOMOND

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION*							POST-CHLORINATION**						
	Cl2		NH3	SO2	RESIDUAL Cl2			Cl2		NH3	SO2	RESIDUAL Cl2		
	Dem.	Dos.***			Free	Comb	Total	Dem.	Dos.			Free	Comb	Total
1		3.65			2.47							2.26		
2		3.55			2.82							1.87		
3		3.60			1.61							2.38		
4		3.85			1.78							2.13		
5		3.85			N/A							N/A		
6		3.85			N/A							N/A		
7		3.73			2.55							1.58		
8		3.62			2.24							1.82		
9		3.92			2.04							1.84		
10		3.82			2.10							2.02		
11		4.06			2.15							1.73		
12		4.06			N/A							N/A		
13		4.06			N/A							N/A		
14		3.86			2.20							1.98		
15		3.82			2.04							1.97		

* Free Residual measured 12 m d/s from point of injection

** Free Residual measured immediately d/s of reservoir

*** Constitutes total chlorine dosage applied for pre and post-chlorination

TABLE 3.2 (cont'd)

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION*							POST-CHLORINATION**						
	Cl2		NH3	SO2	RESIDUAL Cl2			Cl2		NH3	SO2	RESIDUAL Cl2		
	Dem.	Dos.***			Free	Comb	Total	Dem.	Dos.			Free	Comb	Total
16		4.03			2.52							1.92		
17		3.70			N/A							2.04		
18		3.90			2.06							2.02		
19		3.90			N/A							N/A		
20		3.90			N/A							N/A		
21		3.70			2.15							2.10		
22		3.71			2.27							2.16		
23		3.57			2.04							2.01		
24		3.54			2.10							1.97		
25		3.65			2.02							1.93		
26		3.65			N/A							N/A		
27		3.65			N/A							N/A		
28		3.60			2.08							2.10		
29		3.75			1.82							1.75		
30		3.71			2.25							1.74		

TABLE 3.2: DISINFECTION PROFILE (JULY/1986)-LOCH LOMOND
MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION*							POST-CHLORINATION**						
	Cl2		NH3	SO2	RESIDUAL Cl2			Cl2		NH3	SO2	RESIDUAL Cl2		
	Dem.	Dos.***			Free	Comb	Total	Dem.	Dos.			Free	Comb	Total
1		4.46			N/A							N/A		
2		4.09			2.67							2.43		
3		4.64			2.56							2.06		
4		3.88			2.20							1.98		
5		3.88			N/A							N/A		
6		3.88			N/A							N/A		
7		3.59			2.20							2.03		
8		3.65			2.40							1.98		
9		3.87			2.47							2.21		
10		3.96			2.30							2.10		
11		4.15			2.40							2.10		
12		4.15			N/A							N/A		
13		4.15			N/A							N/A		
14		3.90			2.10							2.05		
15		4.10			2.40							2.14		

* Free Residual measured 12 m d/s from point of injection

** Free Residual measured immediately d/s of reservoir

*** Constitutes total chlorine dosage applied for pre and post-chlorination

TABLE 3.2 (cont'd)

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION*							POST-CHLORINATION**						
	Cl2		NH3	SO2	RESIDUAL Cl2			Cl2		NH3	SO2	RESIDUAL Cl2		
	Dem.	Dos.***			Free	Comb	Total	Dem.	Dos.			Free	Comb	Total
16		3.89			2.30							2.22		
17		3.64			2.45							1.99		
18		3.89			2.45							2.12		
19		3.89			N/A							N/A		
20		3.89			N/A							N/A		
21		3.82			2.05							2.20		
22		4.30			2.20							2.10		
23		3.96			2.05							2.54		
24		4.23			2.38							2.72		
25		4.13			2.35							2.45		
26		4.13			N/A							N/A		
27		4.13			N/A							N/A		
28		3.24			2.15							2.10		
29		3.63			2.03							2.28		
30		4.14			2.25							2.07		
31		3.98			2.28							2.05		

TABLE 3.2: DISINFECTION PROFILE (OCT/1986)-LOCH LOMOND

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION*							POST-CHLORINATION**						
	Cl2		NH3	SO2	RESIDUAL Cl2			Cl2		NH3	SO2	RESIDUAL Cl2		
	Dem.	Dos.***			Free	Comb	Total	Dem.	Dos.			Free	Comb	Total
1		4.60			2.41							2.36		
2		4.59			2.84							2.29		
3		4.56			2.27							2.25		
4		4.60			N/A							N/A		
5		4.60			N/A							N/A		
6		4.68			2.20							2.25		
7		4.57			2.34							2.34		
8		4.73			2.58							2.37		
9		4.48			2.47							2.35		
10		4.78			2.65							2.44		
11		4.78			N/A							N/A		
12		N/A			N/A							N/A		
13		4.78			N/A							N/A		
14		4.40			2.65							2.60		
15		4.35			2.38							2.16		

TABLE 3.2 (cont'd)

MOE WPOS PROTOCOL

DATE	PRE-CHLORINATION* Cl2 Dem.	Cl2 Dos.***	NH3	SO2	RESIDUAL Cl2 Free	Comb	Total	POST-CHLORINATION** Cl2 Dem.	Cl2 Dos.	NH3	SO2	RESIDUAL Cl2 Free	Comb	Total
16		4.39			2.39							2.23		
17		4.35			2.53							2.22		
18		4.35			N/A							N/A		
19		4.35			N/A							N/A		
20		4.18			2.45							2.30		
21		4.23			2.18							2.43		
22		4.21			2.50							2.07		
23		4.49			2.10							1.98		
24		4.23			2.26							2.07		
25		4.23			N/A							N/A		
26		4.23			N/A							N/A		
27		4.22			2.31							2.17		
28		4.10			2.35							1.80		
29		3.63			2.10							2.05		
30		3.96			2.02							1.93		
31		3.92			2.01							1.87		

TABLE 5

WATER PLANT OPTIMIZATION STUDY
"PARTICULATE COUNTING, SUSPENDED SOLIDS AND ALGAE COUNTS"

TABLE 5.0: ALGAE COUNT

NO DATA AVAILABLE FOR ALGAE COUNTS

MONTH	COUNT				
JAN	Max. Min. Avg. No. Tests				
FEB	Max. Min. Avg. No. Tests				
MAR	Max. Min. Avg. No. Tests				
APR	Max. Min. Avg. No. Tests				
MAY	Max. Min. Avg. No. Tests				
JUN	Max. Min. Avg. No. Tests				

<u>NOTE</u>: Three consecutive years of data are required, beginning on the left with the current year. Document source of information. All units ASU.

TABLE 5.0 (cont'd.)

NO DATA AVAILABLE FOR ALGAE COUNTS

MONTH	COUNT				
JUL	Max. Min. Avg. No. Tests				
AUG	Max. Min. Avg. No. Tests				
SEP	Max. Min. Avg. No. Tests				
OCT	Max. Min. Avg. No. Tests				
NOV	Max. Min. Avg. No. Tests				
DEC	Max. Min. Avg. No. Tests				

NOTE: Three consecutive years of data are required, beginning on the left with the current year. Document source of information. All units ASU.

TABLE 4

WATER PLANT OPTIMIZATION STUDY
"WATER QUALITY SUMMARY"

WPOS

PLANT LOCH LOMOND WATER QUALITY - 4-YEAR SUMMARY ( )

GENERAL CHEMISTRY		1983 MAX	1983 MIN	1983 AVE	1984 MAX	1984 MIN	1984 AVE	19__ MAX	19__ MIN	19__ AVE	1986 MAX	1986 MIN	1986 AVE	DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
GENERAL CHEMISTRY															
ALKALINITY	R	21.81	18.56	20.57	25.06	16.5	20.81				25.06	21.71	22.61	0.2	
mg/L	T	50.71	23.69	36.28	30.9	18.5	24.36				28.89	21.05	24.57	mg/L	
AMMONIUM TOTAL	R													0.05	
mg/L	T													mg/L	
CALCIUM	R													0.1	
mg/L	T													mg/L	
CHLORIDE	R	2.70	.30	.95	.40	.25	.36				.44	.31	.37	0.2	250
mg/L	T	4.05	2.6	3.1	3.9	3.0	3.34				3.86	3.05	3.44	mg/L	mg/L
COLOUR TCU HAZEN UNITS	R	28.5	21.0	23.8	25	20	23.11				19	16.3	17.33	0.5	5
	T	17.0	9.0	13.8	16	8	11.09				10	5	7.47	TCU	TCU
CONDUCTIVITY	R	59.5	54.5	56.5							62.33	55	57.45	0.01	
umho/cm	T	127	69	91.9							73.66	62	69.9	UMHO/CM	
FIELD CHLORINE (COMBINED)	R													0.1	
mg/L	T													mg/L	
FIELD CHLORINE (FREE)	R													0.1	
mg/L	T													mg/L	
FIELD CHLORINE (TOTAL)	R													0.1	
mg/L	T													mg/L	
FIELD PH	R													0.2	
	T														

WPOS

PLANT LOCH LOMOND WATER QUALITY - 4-YEAR SUMMARY ( )

GENERAL CHEMISTRY (Cont'd)		1983			1984			19__			1986			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
FIELD TEMPERATURE	R	12.23	3.15	7.54	15.24	2.86	8.03				12.95	2.00	6.22		
°C	T														
FIELD TURBIDITY	R														1 FTU
FTU	T														
FLUORIDE	R													0.01	2.4
mg/L	T													mg/L	mg/L
HARDNESS	R	26.46	18.43	23.43	25.74	19.21	23.72				31.2	19.53	25.57	0.5	
mg/L	T	57.26	29.91	42.04	32.5	20.49	29.43				32.08	23.3	28.45	mg/L	
MAGNESIUM	R													0.05	
mg/L	T													mg/L	c
NITRATE	R													0.05	10 mg/L
mg/L	T													mg/L	as N
NITRITE	R													0.005	1 mg/L
mg/L	T													mg/L	as N
NITROGEN TOTAL KJELDAHL	R													0.1	0.15
mg/L	T													mg/L	mg/L *
PH	R	7.29	6.98	7.09	7.41	7.11	7.31				7.45	7.09	7.28		
	T	9.04	7.98	8.47	9.9	7.5	8.54				8.69	7.43	8.16		
PHOSPHORUS FILTERED REACTIVE	R													0.01	
mg/L	T													mg/L	

MPOS

PLANT LOCH LOMOND WATER QUALITY - 4-YEAR SUMMARY ( )

GENERAL CHEMISTRY (Cont'd)		1983 MAX	1983 MIN	1983 AVE	1984 MAX	1984 MIN	1984 AVE	19__ MAX	19__ MIN	19__ AVE	1986 MAX	1986 MIN	1986 AVE	DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
PHOSPHORUS TOTAL	R													0.01	
mg/L	T													mg/L	
SODIUM	R													0.1	
mg/L	T													mg/L	
TOTAL SOLIDS	R													1	
mg/L	T													mg/L	
TURBIDITY	R	.79	.36	.49	.62	.25	.45				1.08	.28	.53	0.01	1
FTU	T	1.12	.51	.79	.65	.25	.47				.63	.28	.49	FTU	FTU
METALS															
ALUMINUM	R													0.003	
mg/L	T													mg/L	
ARSENIC	R													0.001	0.05
mg/L	T													mg/L	mg/L
BARIUM	R													0.001	1
mg/L	T													mg/L	mg/L
BERYLLIUM	R													0.001	
mg/L	T													mg/L	
BORON	R													0.02	5
mg/L	T													mg/L	mg/L
CADMIUM	R													0.0003	0.005
mg/L	T													mg/L	mg/L

WPOS

PLANT LOCH LOMOND WATER QUALITY - 4-YEAR SUMMARY (   )

METALS (Cont'd)			1983			1984			19__			1986			OWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
			MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
CHROMIUM	mg/L	R													0.001 mg/L	0.05 mg/L
		T														
COBALT	mg/L	R													0.001 mg/L	
		T														
COPPER	mg/L	R													0.001 mg/L	1 mg/L
		T														
CYANIDE	mg/L	R													0.001 mg/L	0.2 mg/L
		T														
IRON	mg/L	R	.80	.05	.17	.10	.05	.06				.16	.05	.071	0.002 mg/L	0.3 mg/L c
		T	.15	.06	.10	.10	.05	.06				.10	.05	.06		
LEAD	mg/L	R													0.003 mg/L	0.05 mg/L
		T														
MANGANESE	mg/L	R													0.001 mg/L	0.05 mg/L
		T														
MOLYBDENUM	mg/L	R													0.001 mg/L	
		T														
MERCURY	ug/L	R													0.01 ug/L	1 ug/L
		T														
NICKEL	mg/L	R													0.002* mg/L	
		T														

WPOS

PLANT LOCH LOMOND WATER QUALITY - 4-YEAR SUMMARY ( )

METALS (Cont'd)		1983			1984			19__			1986			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
SELENIUM	R													0.001	0.01
mg/L	T													mg/L	mg/L
STRONTIUM	R													0.001	
mg/L	T													mg/L	
TIN	R														
(no units available)	T														
URANIUM	R													0.002	.02
mg/L	T													mg/L	mg/L t
VANADIUM	R													0.001	
mg/L	T													mg/L	
ZINC	R													0.001	5
mg/L	T													mg/L	mg/L h
PURGEABLES															
BENZENE	R													1	10
ug/L	T													ug/L	ug/L h
BROMOFORM	R													1	350
ug/L	T													ug/L	ug/L ++
CARBON TETRACHLORIDE	R				0	0	0							1	3
ug/L	T				0	0	0							ug/L	ug/L h
CHLOROBENZENE	R													1	100-300
ug/L	T													ng/L	ng/L h*

WPOS

PLANT LOCH LOMOND WATER QUALITY - 4-YEAR SUMMARY ( )

PURGEABLES (Cont'd)		1983 MAX	1983 MIN	1983 AVE	1984 MAX	1984 MIN	1984 AVE	19__ MAX	19__ MIN	19__ AVE	1986 MAX	1986 MIN	1986 AVE	DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
CHLORODIBROMOMETHANE	R				0	0	0				0	0	0	1	350
ug/L	T				0	0	0				2	0	17	ug/L	ug/L ++
CHLOROFORM	R				0	0	0							1	350
ug/L	T				113	69	93.3							ug/L	ug/L ++
1,2-DICHLOROBENZENE	R													1	400
ug/L	T													ug/L	ug/L e
1,3-DICHLOROBENZENE	R													1	400
ug/L	T													ug/L	ug/L e
1,4-DICHLOROBENZENE	R													1	400
ug/L	T													ug/L	ug/L e
DICHLOROBROMOMETHANE	R				0	0	0				0	0	0	1	350
ug/L	T				3	2	2.6				10	2	6.2	ug/L	ug/L ++
1,1-DICHLOROETHANE	R													1	
ug/L	T													ug/L	
1,2-DICHLOROETHANE	R													1	10
ug/L	T													ug/L	ug/L h
1,1-DICHLOROETHYLENE	R													1	.3
ug/L	T													ug/L	ug/L h
T,1,2-DICHLOROETHYLENE	R													1	
ug/L	T													ug/L	

TABLE 4

WPOS

PLANT LOCH LOMOND WATER QUALITY - 4-YEAR SUMMARY ( )

PURGEABLES (Cont'd)		19 83			1984			19__			19 86			OWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
DICHLOROMETHANE	R													5	40
ug/L	T													ug/L	ug/L c
1,2 DICHLOROPROPANE	R													1	
ug/L	T													ug/L	
ETHYLBENZENE	R													1	1400
ug/L	T													ug/L	ug/L e
ETHYLENE DIBROMIDE	R														
ug/L	T														
M-XYLENE	R													1	620
ug/L	T													ug/L	ug/L c
O-XYLENE	R													1 ug/L	620
ug/L	T														ug/L c
P-XYLENE	R													1	620
ug/L	T													ug/L	ug/L c
TOLUENE	R													1	100
ug/L	T													ug/L	ug/L c
1,1,2,2-TETRACHLOROETHANE	R													1	1.7
ug/L	T													ug/L	ug/L e
TETRACHLOROETHYLENE	R				0	0	0							1	10
ug/L	T				0	0	0							ug/L	ug/L h

TABLE 4

WPOS

PLANT LOCH LOMOND WATER QUALITY - 4-YEAR SUMMARY ( )

PURGEABLES (Cont'd)		19 83			19 84			19__			1986			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
1,1,1-TRICHLOROETHANE	R													1	1000
ug/L	T													ug/L	ug/L c
1,1,2-TRICHLOROETHANE	R													1	6
ug/L	T													ug/L	ug/L e
TRICHLOROETHYLENE	R				0	0	0							1	30
ug/L	T				0	0	0							ug/L	ug/L h
TOTAL TRIHALOMETHANES	R				0	0	0				0	0	0	3	350
ug/L	T				116	71	95				308	89	220	ug/L	ug/L ++
TRIFLUOROCHLOROTOLUENE	R													1	
ug/L	T													ug/L	
ORGANOCHLORINES															
ALDRIN	R													1	700
ng/L	T													ng/L	ng/L **
ALPHA BHC	R													1	700
ng/L	T													ng/L	ng/L c
ALPHA CHLORDANE	R													2	700
ng/L	T													ng/L	ng/L ***
BETA BHC	R													1	300
ng/L	T													ng/L	ng/L c
DIELDRIN	R													2	700
ng/L	T													ng/L	ng/L **

TABLE 4

WPOS

PLANT Loch Lomond WATER QUALITY - 4-YEAR SUMMARY ( )

ORGANOCHLORINES (Cont'd)		1983			1984			19__			1986			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
ENDRIN	R													4	200
ng/L	T													ng/L	ng/L
GAMMA CHLORDANE	R													2	700
ng/L	T													ng/L	ng/L ***
HEPTACHLOR EPOXIDE	R													1	3000 +++
ng/L	T													ng/L	ng/L
HEPTACHLOR	R													1	3000
ng/L	T													ng/L	ng/L +++
HEXACHLOROBENZENE	R													1	10
ng/L	T													ng/L	ng/L h
HEXACHLOROBUTADIENE	R														
ug/L	T														
HEXACHLOROETHANE	R													1	19000
ng/L	T													ng/L	ng/L e
LINDANE	R													1	4000
ng/L	T													ng/L	ng/L
METHOXYCHLOR	R													5	100000
ng/L	T													ng/L	ng/L
MIREX	R													5	
ng/L	T													ng/L	

TABLE 4

WPOS

PLANT LOCH LOMOND WATER QUALITY - 4-YEAR SUMMARY (   )

ORGANOCHLORINES (Cont'd)		19 83			19 84			19__			19 86			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
OCTACHLOROSTYRENE ng/L	R													1	
	T													ng/L	
O,P-DDT ng/L	R													5	30000
	T													ng/L	ng/L d
OXYCHLORDANE ng/L	R													2	
	T													ng/L	
PCB TOTAL ng/L	R													20	3000
	T													ng/L	ng/L t
PENTACHLOROBENZENE ng/L	R													1	74000
	T													ng/L	ng/L e
P,P-DDD ng/L	R													5	d
	T													ng/L	
P,P-DDE ng/L	R													1	d
	T													ng/L	
P,P-DDT ng/L	R													5	d
	T													ng/L	
1,2,3,4-TETRACHLOROBENZENE ng/L	R													1	
	T													ng/L	
1,2,3,5-TETRACHLOROBENZENE ng/L	R													1	
	T													ng/L	

TABLE 4

MPOS

PLANT LOCH LOMOND WATER QUALITY - 4-YEAR SUMMARY ( )

ORGANOCHLORINES (Cont'd)		1983 MAX	1983 MIN	1983 AVE	1984 MAX	1984 MIN	1984 AVE	19__ MAX	19__ MIN	19__ AVE	1986 MAX	1986 MIN	1986 AVE	OWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
1,2,4,5-TETRACHLOROBENZENE	R													1	38000
ng/L	T													ng/L	ng/L e
THIODAN I	R													2	74000
ng/L	T													ng/L	ng/L ea
THIODAN II	R													4	74000
ng/L	T													ng/L	ng/L ea
THIODAN SULPHATE	R													4	
ng/L	T													ng/L	
TOXAPHENE	R														
(no units available)	T														
1,2,3-TRICHLOROBENZENE	R													5	10000
ng/L	T													ng/L	ng/L y
1,2,4-TRICHLOROBENZENE	R													5	15000
ng/L	T													ng/L	ng/L y
1,3,5-TRICHLOROBENZENE	R													5	10000
ng/L	T													ng/L	ng/L y
2,3,6-TRICHLOROTOLUENE	R													5	
ng/L	T													ng/L	
2,4,5-TRICHLOROTOLUENE	R													5	10000
ng/L	T													ng/L	ng/L g

TABLE 4

WPOS

PLANT LOCH LOMOND WATER QUALITY - 4-YEAR SUMMARY ( )

ORGANOCHLORINES (Cont'd)		1983			1984			19__			19 86			OWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
2,6,A-TRICHLOROTOLUENE	R													5	
mg/L	T													ng/L	
TRIAZINES															
ALACHLOR	R														
ng/L	T														
AMETRINE	R													50	
ng/L	T													ng/L	
ATRATONE	R														
ng/L	T														
ATRAZINE	R													50	46000
ng/L	T													ng/L	ng/L !
BLADEX	R													100	10000
ng/L	T													ng/L	ng/L !
METOLACHLOR	R														
ng/L	T														
PROMETONE	R													50	
ng/L	T													ng/L	
PROMETRYNE	R													50	1000
ng/L	T													ng/L	ng/L !
PROPAZINE	R													50	
ng/L	T													ng/L	

TABLE 4

WPOS

PLANT LOCH LOMOND **WATER QUALITY - 4-YEAR SUMMARY (** **)**

TRIAZINES (Cont'd)		1983			19 84			19__			19 86			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
SENCOR	R													100	
ng/L	T													ng/L	
SIMAZINE	R													50	10000
ng/L	T													ng/L	ng/L
SPECIAL PESTICIDES															
2,4-D	R													100	100000
ng/L	T													ng/L	ng/L
2,4-D BUTYRIC ACID	R													200	18000
ng/L	T													ng/L	ng/L
DICAMBA	R													100	87000
ng/L	T													ng/L	ng/L
PENTACHLOROPHENOL	R													50	10000
ng/L	T													ng/L	ng/L
PICLORAM	R													100	
ng/L	T													ng/L	
2,4-D PROPIONIC ACID	R													100	
ng/L	T													ng/L	
SILVEX	R													50	10000
ng/L	T													ng/L	ng/L
2,4,5-T	R													50	
ng/L	T													ng/L	

TABLE 4

WPOS

PLANT LOCH LOMOND WATER QUALITY - 4-YEAR SUMMARY ( )

SPECIAL PESTICIDES (Cont'd)		1983			1984			19__			1986			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
,4,5-TETRACHLOROPHENOL	R													50	
ng/L	T													ng/L	
,5,6-TETRACHLOROPHENOL	R													50	
ng/L	T													ng/L	
,4-TRICHLOROPHENOL	R													100	
ng/L	T													ng/L	
,5-TRICHLOROPHENOL	R													50	
ng/L	T													ng/L	
,6-TRICHLOROPHENOL	R													50	10000
ng/L	T													ng/L	ng/L h
GANOPHOSPHOROUS PESTICIDES															
AZINON	R													50	14000
ng/L	T													ng/L	ng/L
CHLOROVOS	R														
ng/L	T														
RSBAN	R														
ng/L	T														
HION	R														
ng/L	T														
THION	R														
ng/L	T														

TABLE 4

MPOS

PLANT LOCH LOMOND WATER QUALITY - 4-YEAR SUMMARY ( )

ORGANOPHOSPHOROUS PESTICIDES (Cont'd)		19 83			19 84			19__			19 86			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
MALATHION	R														
ng/L	T														
METHYLPARATHION	R													50	7000
ng/L	T													ng/L	ng/L
METHYLTRITHION	R														
ng/L	T														
MEVINPHOS	R														
ng/L	T														
PARATHION	R													50	35000
ng/L	T													ng/L	ng/L
PHORBATE	R														
ng/L	T														
RELDAN	R														
ng/L	T														
RONNEL	R														
ng/L	T														
MASS SPEC.															
DI-N-BUTYL PHTHALATE	R													0.1	34000
ug/L	T													ug/L	ug/L

TABLE 4

WPOS

PLANT LOCH LOMOND WATER QUALITY - 4-YEAR SUMMARY ( ).

MASS SPEC. (Cont'd)		19 83			19 84			19__			19 86			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
N-DICHLOROMETHYLENE-PENTACHLOROANALINE ug/L	R													0.1 ug/L	
	T														
DIPHENYL ETHER ug/L	R													0.1 ug/L	
	T														
FLUORANTHENE ug/L	R													0.1 ug/L	
	T														
HEXACHLOROPROPENE ug/L	R													0.1 ug/L	
	T														
METHYL PHENANTHRENE ug/L	R													0.1 ug/L	
	T														
NAPHTHALENE ug/L	R													0.1 ug/L	
	T														
PENTACHLOROBUTADIENE ug/L	R													0.1 ug/L	
	T														
PENTACHLOROPROPANE ug/L	R													0.1 ug/L	
	T														
PENTACHLOROPROPENE ug/L	R													0.1 ug/L	
	T														
PYRENE ug/L	R													0.1 ug/L	
	T														

TABLE 4

WPOS

PLANT LOCH LOMOND WATER QUALITY - 4-YEAR SUMMARY ( )

MASS SPEC. (Cont'd)		1983			1984			19__			1986			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
TETRACHLORBUTANE	R													0.1	
ug/L	T													ug/L	
TETRACHLOROBIPHENYL	R													0.1	
ug/L	T													ug/L	
BACTERIA															
RAW WATER:															
TOTAL COLIFORM MF	R														
count/100mL															
TOTAL COLIFORM BKGD	R														
count/100mL															
FECAL COLIFORM MF	R													0	0/0.1
count/100mL															mL
STANDARD PLATE COUNT MF	R													0	500
count/100mL															
TREATED WATER:															
PRESENT/ABSENT TEST	T														
TOTAL COLIFORM BACKGROUND MF	T													0	OWDO
count/100mL															Bact I

TABLE 4

WPOS

PLANT LOCH LOMOND WATER QUALITY - 4-YEAR SUMMARY ( )

BACTERIA (Cont'd)		1983			1984			19__			1986			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
TREATED WATER: (Cont'd)															
FECAL COLIFORM MF count/100mL	T													0	ODWO Bact I
STANDARD PLATE COUNT MF count/100mL	T														
IF PRESENT/ABSENT TEST POSITIVE:															
COLIFORM P/A	T														
FECAL COLIFORM P/A	T														
E. COLI P/A	T														
AROMONAS P/A	T														
STAPH. AUREUS P/A	T														

A0106A/eal

Table A - Footnotes

1 = see individual footnotes for Agency of guideline origin

c = California State Department of Health Action Level

d = OWDO for DDT (contains other isomers such as OPDDT and PPDDT)

e = USEPA ambient guideline

ea = United States Environmental Protection Agency (USEPA) ambient level for endosulfan (contains other isomers)

ep = USEPA proposed maximum contaminant level for drinking water

g = suggested Health and Welfare Canada/Ontario Ministry of the Environment guideline value

h = World Health Organization (WHO) guideline

h* = World Health Organization (WHO) Odour Threshold

mg/L = milligrams per litre, parts per million, (ppm)

ng/L = nanograms per litre, parts per trillion, (ppt)

Presence/Absence = microbiological test to indicate presence or absence of coliform bacteria

R = raw water

T = Treated Drinking Water

t = OOWO interim maximum acceptable concentration, (IMAC)

ug/L = micrograms per litre, parts per billion, (ppb)

y = New York State (Taste and Odour) proposed drinking water guideline

++ = total Trihalomethanes

+++ = combined total: Heptachlor and Heptachlor Epoxide

* = if other than DWSP Detection Limit

** = total of Aldrin and Dieldrin

*** = Chlordane is a mixture of alpha and gamma isomers

I = Ministry of the Environment and Health and Welfare Canada, (IMAC)

TABLE 6

WATER PLANT OPTIMIZATION STUDY
"BACTERIOLOGICAL TESTING"

TABLE 6.0: LOCH LOMOND
BACTERIOLOGICAL TESTING (1983)

MOE WPOS PROTOCOL

		TOTAL COLIFORM					FECAL COLIFORM					FECAL STREPTOCOCCUS			
		Absent	1-5	6-100	101-5000	>5000	Absent	1-5	6-10	11-500	>500	Absent	<2	2-50	>50
JAN	R	–	4	–	–	–	–	4	–	–	–	–	3	1	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
FEB	R	–	4	–	–	–	–	4	–	–	–	–	4	–	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
MAR	R	–	4	–	–	–	–	4	–	–	–	–	4	–	–
	T	5	–	–	–	–	5	–	–	–	–	5	–	–	–
APR	R	–	3	1	–	–	–	4	–	–	–	–	4	–	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
MAY	R	–	4	–	–	–	–	4	–	–	–	–	4	–	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
JUN	R	–	4	–	–	–	–	4	–	–	–	–	3	1	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
JUL	R	–	4	–	–	–	–	4	–	–	–	–	3	1	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
AUG	R	–	–	2	3	–	–	5	–	–	–	–	3	2	–
	T	5	–	–	–	–	5	–	–	–	–	5	–	–	–
SEP	R	–	–	2	2	–	–	4	–	–	–	–	3	1	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
OCT	R	–	3	1	–	–	–	4	–	–	–	–	3	1	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
NOV	R	–	3	2	–	–	–	5	–	–	–	–	3	2	–
	T	6	–	–	–	–	6	–	–	–	–	6	–	–	–
DEC	R	–	4	–	–	–	–	4	–	–	–	–	3	1	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–

NOTE: All results are for 100 mL samples; tests carried out at MOE Lab
Figures indicate number of tests
R = Raw Water.
T = Treated Water.

TABLE 6.1: LOCH LOMOND
BACTERIOLOGICAL TESTING (1984)

MOE WPOS PROTOCOL

		TOTAL COLIFORM					FECAL COLIFORM					FECAL STREPTOCOCCUS			
		Absent	*1-5*	*6-100*	*101-5000*	*>5000*	*Absent*	*1-5*	*6-10*	*11-500*	*>500*	*Absent*	*<2*	*2-50*	*>50*
JAN	*R*	–	5	–	–	–	–	5	–	–	–	–	5	–	–
	T	5	–	–	–	–	5	–	–	–	–	5	–	–	–
FEB	*R*	–	4	–	–	–	–	4	–	–	–	–	3	1	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
MAR	*R*	–	4	–	–	–	–	4	–	–	–	–	4	–	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
APR	*R*	–	4	–	–	–	–	4	–	–	–	–	4	–	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
MAY	*R*	–	5	–	–	–	–	5	–	–	–	–	5	–	–
	T	5	–	–	–	–	5	–	–	–	–	5	–	–	–
JUN	*R*	–	2	1	1	–	–	3	1	–	–	–	–	3	1
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
JUL	*R*	–	3	1	–	–	–	4	–	–	–	–	3	1	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
AUG	*R*	–	–	4	–	–	–	4	–	–	–	–	3	1	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
SEP	*R*	–	3	–	–	–	–	3	–	–	–	–	2	1	–
	T	3	–	–	–	–	3	–	–	–	–	3	–	–	–
OCT	*R*	–	3	2	–	–	–	5	–	–	–	–	5	–	–
	T	5	–	–	–	–	5	–	–	–	–	5	–	–	–
NOV	*R*	–	4	–	–	–	–	4	–	–	–	–	4	–	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
DEC	*R*	–	3	–	–	–	–	3	–	–	–	–	3	–	–
	T	3	–	–	–	–	3	–	–	–	–	3	–	–	–

NOTE: All results are for 100 mL samples; tests carried out at MOE Lab
Figures indicate number of tests
R = Raw Water.
T = Treated Water.

TABLE 6.2: LOCH LOMOND
BACTERIOLOGICAL TESTING (1985)

MOE WPOS PROTOCOL

		TOTAL COLIFORM					FECAL COLIFORM					FECAL STREPTOCOCCUS			
		Absent	1-5	6-100	101-5000	>5000	Absent	1-5	6-10	11-500	>500	Absent	<2	2-50	>50
JAN	R	–	5	–	–	–	–	5	–	–	–	–	5	–	–
	T	5	–	–	–	–	5	–	–	–	–	5	–	–	–
FEB	R	–	4	–	–	–	–	4	–	–	–	–	4	–	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
MAR	R	–	5	–	–	–	–	5	–	–	–	–	3	2	–
	T	6	–	–	–	–	6	–	–	–	–	6	–	–	–
APR	R	–	3	–	–	–	–	3	–	–	–	–	1	2	–
	T	3	–	–	–	–	3	–	–	–	–	3	–	–	–
MAY	R	–	5	–	–	–	–	5	–	–	–	–	5	–	–
	T	5	–	–	–	–	5	–	–	–	–	5	–	–	–
JUN	R	–	4	–	–	–	–	4	–	–	–	–	4	–	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
JUL	R	–	3	1	–	–	–	4	–	–	–	–	3	1	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
AUG	R	–	4	–	–	–	–	4	–	–	–	–	4	–	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
SEP	R	–	1	3	–	–	–	4	–	–	–	–	1	3	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
OCT	R	–	1	2	–	–	–	3	–	–	–	–	1	2	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
NOV	R	–	4	–	–	–	–	4	–	–	–	–	4	–	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
DEC	R	–	3	–	–	–	–	3	–	–	–	–	3	–	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–

NOTE: All results are for 100 mL samples; tests carried out at MOE Lab
Figures indicate number of tests
R = Raw Water.
T = Treated Water.

TABLE 6.3: LOCH LOMOND
BACTERIOLOGICAL TESTING (1986)

MOE WPOS PROTOCOL

		TOTAL COLIFORM					FECAL COLIFORM					FECAL STREPTOCOCCUS			
		Absent	1-5	6-100	101-5000	>5000	Absent	1-5	6-10	11-500	>500	Absent	<2	2-50	>50
JAN	R	–	4	–	–	–	–	4	–	–	–	–	2	2	–
	T	5	–	–	–	–	5	–	–	–	–	5	–	–	–
FEB	R	–	4	–	–	–	–	4	–	–	–	–	–	4	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
MAR	R	–	4	–	–	–	–	4	–	–	–	–	1	3	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
APR	R	–	5	–	–	–	–	5	–	–	–	–	4	1	–
	T	5	–	–	–	–	5	–	–	–	–	5	–	–	–
MAY	R	–	4	–	–	–	–	4	–	–	–	–	4	–	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
JUN	R	–	3	1	–	–	–	4	–	–	–	–	4	–	–
	T	5	–	–	–	–	5	–	–	–	–	5	–	–	–
JUL	R	–	4	–	–	–	–	4	–	–	–	–	4	–	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
AUG	R	–	4	–	–	–	–	4	–	–	–	–	4	–	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
SEP	R	–	4	1	–	–	–	5	–	–	–	–	4	1	–
	T	5	–	–	–	–	5	–	–	–	–	5	–	–	–
OCT	R	–	4	–	–	–	–	4	–	–	–	–	4	–	–
	T	4	–	–	–	–	4	–	–	–	–	4	–	–	–
NOV	R	–	2	–	–	–	–	2	–	–	–	–	2	–	–
	T	3	–	–	–	–	3	–	–	–	–	3	–	–	–
DEC	R	–	3	–	–	–	–	3	–	–	–	–	3	–	–
	T	3	–	–	–	–	3	–	–	–	–	3	–	–	–

NOTE: All results are for 100 mL samples; tests carried out at MOE Lab
Figures indicate number of tests
R = Raw Water.
T = Treated Water.

TABLE 7

WATER PLANT OPTIMIZATION STUDY
"ONTARIO DRINKING WATER OBJECTIVES EXCEEDANCE SUMMARY"

TABLE 7.0: ONTARIO DRINKING WATER OBJECTIVES INCLUDING ALUMINUM (TREATED WATER AT PLANT)

DATE	PARAMETER	MEASURED PARAMETER	OBJECTIVE LIMIT
July 7, 1986	Turbidity	1.2 NTU	1.0 NTU

NOTE: List health-related parameters which exceed Ontario Drinking Water

APPENDIX B

OF THUNDER BAY
PUBLIC WORKS
OPERATIONS

LOCH LOMOND WATER TREATMENT PLANT

WEEKLY PERFORMANCE REPORT

PERIOD
FROM Oct. 28 TO Oct. 31 84

	SUN	MON	TUE	WED	THU	FRI	SAT	TOTAL	
RAW WATER									
MAXIMUM RATE - (Mld)	50.0	47.5	51.40	46.3				195.20	4
MINIMUM RATE - (Mld)	26.4	26.8	26.40	28.0				107.6	26.9
TOTAL RATE - (Mld)	31.27	31.53	32.77	32.9				128.47	3
MAXIMUM DAY - (Ml)									
MAXIMUM RATE - (Ml)									
RAW WATER									
TEMPERATURE - (C)	N/A	8°	8°	8°	8			24	8
P.H.		9.9	9.9	9.9					
HARDNESS ($CaCo_3$) mg/l		28.0	29.2	29.2				86.4	28
ALKALINITY ($CaCo_3$) mg/l		21.2	22.0	22.8				66.0	22.0
IRON (Fe) mg/l)									
CHLORIDE (Cl) mg/l									
COLOUR (HAZEN UNITS)									
TURBIDITY (FORMAZIN UNITS)		0.58	0.50	0.53				1.61	0.
CONDUCTIVITY (umHos/cm)									
BACTERIOLOGICAL (T.C.)		*							
ODOUR									
SREENING REMOVAL									
FOREBAY (kg)									
RESERVOIR (kg)									
CHEMICALS USED									
LIME USED (kg)	313	346	329	320				1308	327
LIME DOSAGE (mg/l)	10.0	10.98	10.03	9.72				40.73	10.18
CO2 USED (kg)									
CO2 DOSAGE (mg/l)									
LAKE ELEVATION		285.60						285.60	285.6

REMARKS: No Screen Cleaning completed.

THE CITY OF THUNDER BAY
PUBLIC WORKS
OPERATIONS

LOCH LOMOND WATER TREATMENT PLANT

WEEKLY PERFORMANCE REPORT

PERIOD
FROM JAN 19TH TO JAN 25TH 1986

	SUN	MON	TUE	WED	THU	FRI	SAT	TOTAL	AVG.
W WATER									
XIMUM RATE - (Mld)	47.10	49.30	49.80	49.70	48.70	49.20	48.50	342.30	48.9
NIMUM RATE - (Mld)	18.20	17.50	20.00	19.10	20.00	20.00	24.10	138.90	19.8
TAL RATE - (Mld)	32.47	32.63	32.36	32.17	33.71	32.11	32.11	227.56	32.5
XIMUM DAY - (Ml)					33.71				
XIMUM RATE - (Ml)			49.80						
W WATER									
MPERATURE - (C)	N/A	2°	2°	2°	2°	2°	N/A	10.0°	2.0
H.		7.37	* 7.11	7.15	7.09	7.23		35.95	7.
RDNESS ($CaCo_3$) mg/l		26.8	* 28.0	28.4	26.0	28.0		137.2	27
KALINITY ($CaCo_3$) mg/l		20.8	* 22.0	22.0	22.0	22.8		109.6	21
ON (Fe) mg/l)			*						
LORIDE (Cl) mg/l			*						
LOUR (HAZEN UNITS)			*						
RBIDITY (FORMAZIN UNITS)		0.32	* 0.33	0.31	0.32	0.34		1.62	0.
NDUCTIVITY (umHos/cm)			*						
CTERIOLOGICAL (T.C.)			*						
OUR									
REENING REMOVAL									
OREBAY (kg)					0.75			0.75	0.75
ESERVOIR (kg)					0.25			0.25	0.25
HEMICALS USED									
IME USED (kg)	200	201	199	198	207	197	197	1399.00	199.
IME DOSAGE (mg/l)	6.15	6.15	6.15	6.15	6.15	6.15	6.15	43.05	6.1
O2 USED (kg)									
O2 DOSAGE (mg/l)									
AKE ELEVATION	285.52			285.51		285.50		856.53	285.

EMARKS:

5 3

THE CITY OF THUNDER BAY
PUBLIC WORKS
OPERATIONS

LOCH LOMOND WATER TREATMENT PLANT

WEEKLY PERFORMANCE REPORT

PERIOD
FROM JAN 19TH TO JAN 25TH 1986

	SUN	MON	TUE	WED	THU	FRI	SAT	TOTAL	AVG.
TREATED WATER									
MAXIMUM RATE - (Mld)	47.10	49.30	49.80	49.70	48.70	49.20	48.50	342.30	48.90
MINIMUM RATE - (Mld)	18.20	17.50	20.00	19.10	20.00	20.00	24.10	138.90	19.8
TOTAL RATE - (Mld)	32.47	32.63	32.36	32.17	33.71	32.11	32.11	227.56	32.51
MAXIMUM DAY - (Ml)					33.71				
MAXIMUM RATE - (Ml)			49.80						
TREATED WATER									
TEMPERATURE - (C)	N/A	2°	2°	2°	2°	2°	N/A	10.0°	2.0
P.H.	N/A	9.5	* 9.7	9.6	9.6	9.4	NA	47.8	9.56
HARDNESS ($CaCo_3$) mg/l		28.8	* 32.8	34.0	32.0	32.0		159.6	31
ALKALINITY ($CaCo_3$) mg/l		26.0	* 22.8	28.0	24.4	24.4		125.6	25.1
IRON (Fe) mg/l			*						
CHLORIDE (Cl) mg/l			*						
COLOUR (HAZEN UNITS)		0.40	* 0.38	0.39	0.42	0.41		2.0	0.4
TURBIDITY (FORMAZIN UNITS)		↓	* ↓	↓	↓	↓		↓	↓
CONDUCTIVITY (umHos/cm)			*						
BACTERIOLOGICAL (T.C.)			*						
ODOUR									
TASTE									
DEPOSITION POTENTIAL									
CALCIUM HARDNESS (mg/l)									
DISINFECTION									
CHLORINE USED - (kg)	119	120	125	118	124	120	120	846.00	120.8
DOSAGE - (mg/l)	3.66	3.68	3.85	3.67	3.69	3.75	3.75	26.05	3.72
RESIDUAL-PRE (mg/l)	N/A	2.35	2.30	2.15	2.25	2.39	N/A	11.44	2.29
RESIDUAL-POST (mg/l)	N/A	1.95	2.10	2.01	2.09	2.12	N/A	10.27	2.05
POWER CONSUMPTION		5878.2	5889.5	5900.1	5912.2	5924.4		5544.0	1386.0
DISTRIBUTION SYSTEM									
P.H. (W.P.C.P)		7.63	7.56	7.75	7.54	7.77		38.25	7.65
P.H. (W.F.L.)	N/A	8.15	8.50	8.5	8.5	8.2	N/A	41.85	8.37
ALKALINITY									
CHLORINE RESIDUAL (WPCP mg/l)		0.50	0.50	0.50	0.45	0.55		2.5	0.5
CHLORINE RESIDUAL (WFL mg/l)	N/A	1.45	1.48	1.33	1.40	1.3	N/A	6.93	1.39

THE CITY OF THUNDER BAY
PUBLIC WORKS
OPERATIONS

LOCH LOMOND WATER TREATMENT PLANT

WEEKLY PERFORMANCE REPORT

PERIOD
FROM JAN 26 TO JAN 31 1986

	SUN	MON	TUE	WED	THU	FRI	SAT	TOTAL	AVG
AW WATER									
AXIMUM RATE - (Mld)	49.60	48.80	49.80	49.80	48.90	49.20		296.9	49.
INIMUM RATE - (Mld)	17.60	18.20	19.90	22.90	20.10	19.70		118.40	19.
OTAL RATE - (Mld)	32.11	33.39	33.90	33.44	32.88	33.57		199.29	33.
AXIMUM DAY - (Ml)			33.80						
AXIMUM RATE - (Ml)			49.80						
AW WATER									
EMPERATURE - (C)	N/A	2°	2°	2°	2°	2°		10°	2
.H.		7.16	7.01	7.12	7.03	7.14		35.46	7.
ARDNESS ($CaCo_3$) mg/l		30.0	26.4	29.2	26.8	28.0		140.4	28
LKALINITY ($CaCo_3$) mg/l		20.0	24.0	20.8	22.8	22.0		109.6	21.
RON (Fe) mg/l									
HLORIDE (Cl) mg/l									
OLOUR (HAZEN UNITS)									
URBIDITY (FORMAZIN UNITS)		0.24	0.28	0.23	0.35	0.23		1.33	0.
ONDUCTIVITY (umHos/cm)									
ACTERIOLOGICAL (T.C.)									
OUR									
REENING REMOVAL									
OREBAY (kg)					0.75				0.7
ESERVOIR (kg)					0.25				0.2
HEMICALS USED									
IME USED (kg)	197	205	209	206	202	206		1225.0	204.
IME DOSAGE (mg/l)	6.15	6.15	6.15	6.15	6.15	6.15		36.90	6.
O2 USED (kg)									
O2 DOSAGE (mg/l)									
AKE ELEVATION		285.48			285.48	285.47		5643	285.

EMARKS:

THE CITY OF THUNDER BAY
PUBLIC WORKS
OPERATIONS

LOCH LOMOND WATER TREATMENT PLANT

WEEKLY PERFORMANCE REPORT

PERIOD
FROM JAN 26 TO JAN 31 1986

	SUN	MON	TUE	WED	THU	FRI	SAT	TOTAL	AVG.
TREATED WATER									
MAXIMUM RATE - (Mld)	49.50	48.80	49.80	49.80	48.90	49.20		296.9	49.48
MINIMUM RATE - (Mld)	17.60	18.20	19.90	22.90	20.10	19.70		118.40	19.7
TOTAL RATE - (Mld)	32.11	33.39	33.90	33.44	32.88	33.57		199.29	33.22
MAXIMUM DAY - (Ml)									
MAXIMUM RATE - (Ml)									
TREATED WATER									
TEMPERATURE - (C)	N/A	2°	2°	2°	2°	2°		10°	2
P.H.		9.6	9.8	9.7	9.7	10.0		48.80	9.76
HARDNESS ($CaCo_3$) mg/l		32.0	32.0	30.4	32.0	32.0		158.4	31
ALKALINITY ($CaCo_3$) mg/l		24.8	27.2	24.8	26.4	26.0		129.2	25.8
IRON (Fe) mg/l									
CHLORIDE (Cl) mg/l)									
COLOUR (HAZEN UNITS)									
TURBIDITY (FORMAZIN UNITS)		0.39	0.41	0.30	0.47	0.33		1.9	0.3
CONDUCTIVITY (umHos/cm)									
BACTERIOLOGICAL (T.C.)									
ODOUR									
TASTE									
DEPOSITION POTENTIAL									
CALCIUM HARDNESS (mg/l)		20.8	22.0	22.0	20.4	22.4		107.6	21
DISINFECTION									
CHLORINE USED - (kg)	120	123	125	126	127	119		740.0	123
DOSAGE - (mg/l)	3.75	3.67	3.69	3.77	3.67	3.59		22.14	3.69
RESIDUAL-PRE (mg/l)	N/A	2.40	2.23	2.21	2.21	2.35		11.40	2.
RESIDUAL-POST (mg/l)	N/A	2.05	2.13	2.04	2.12	2.12		10.46	2.08
POWER CONSUMPTION		5959.9	5971.1	5982.8	5994.5	6006.2		29914.5	5982.9
DISTRIBUTION SYSTEMS									
P.H. (W.P.C.P)		7.18	7.31	7.4	7.67	7.63		37.19	7.44
P.H. (W.F.L.)	N/A	LINE DOWN N/A	8.5	8.5	8.5	9.0		34.5	8.6
ALKALINITY									
CHLORINE RESIDUAL (WPCPmg/l)		0.40	0.40	0.45	0.48	0.45		2.18	0.44
CHLORINE RESIDUAL (WFL mg/l)	N/A	1.40	1.4	1.35	1.40	1.40		6.95	1.3

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1.42

THE CORPORATION OF THE CITY OF THUNDER BAY
PUBLIC WORKS DEPARTMENT

WATER TREATMENT PLANTS
DAILY STATION REPORT

PERIOD: FROM Dec 8 TO 12, 1980

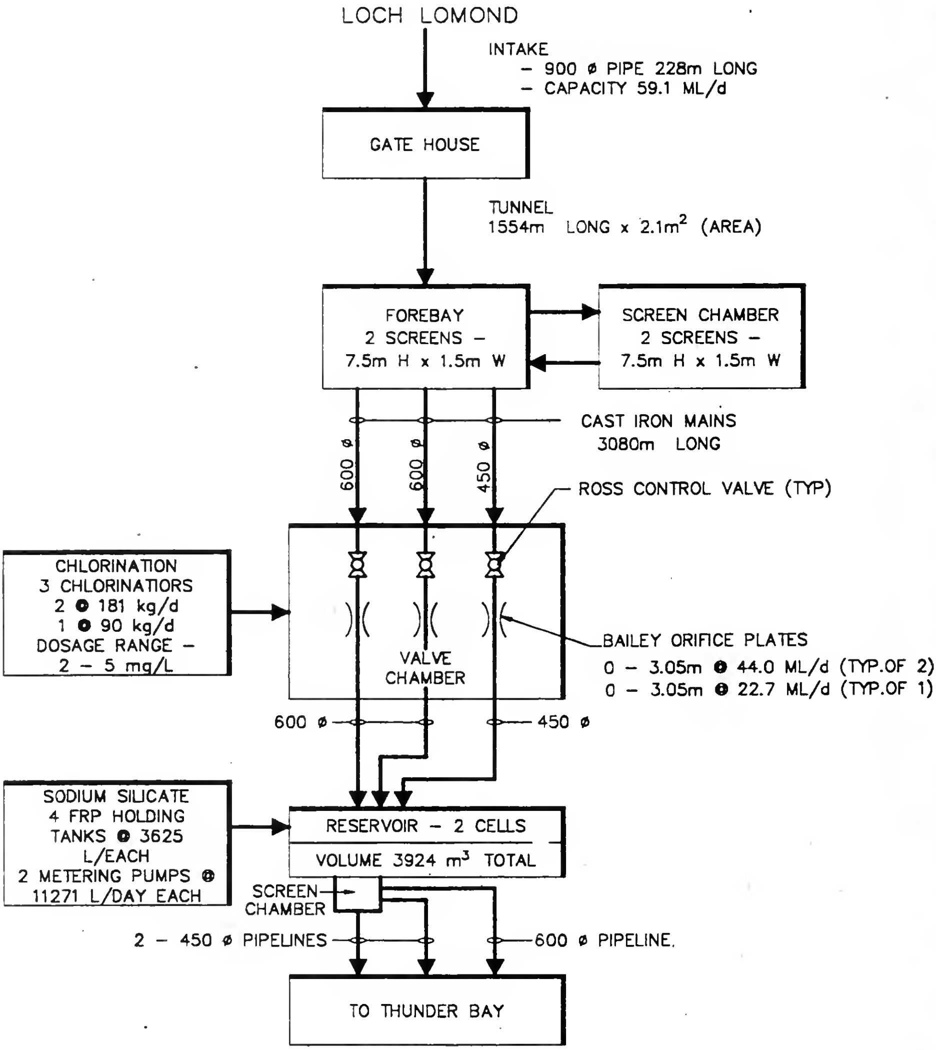
...ION LOCH LOMOND	MONDAY TIME 0950 PUMP MOTOR	TUESDAY TIME 0945 PUMP MOTOR	WEDNESDAY TIME 0940 PUMP MOTOR	THURSDAY TIME 09.35 PUMP MOTOR	FRIDAY TIME 1000 PUMP MO...
...ant Flow ml/d	29.36 Av	30.36	30.92	30.43	31.71
...ter Temp.	3°	3°	2°	2°	2°
Reading	9.2/7.32	9.0/ ~~6~~95	9.2/ 7.15	SINK 9.3/7.14	9.4/7.43
...ne Used ...o	392 Av	324	359	335	396
...ne Dosage ...g/l	13.35	10.67	12.81	10.6	12.49
...BIDITY ...RA WATER	.60	.60	.62	.68	.63
...T CL^2 RESIDUAL ...L	202+19 = 2.21	203+19 2.22	208+17 2.25	205+14 = 2.19	204+11 = 2.15
...Used Kg/Day	113 Av	110	111	118	116
BALANCE LEFT IN SERVICE	0/125	1883/60	1618/20	1376	1120/2000
...Dosage ...g/l	3.85 ~~[illegible]~~	3.62	3.59	3.9	3.66
...CL^2 RESIDUAL	204+10 = 2.14	206+11 = 2.17	235+8 = 2.43	2.45+.11 2.56	182+7 1.89
...Level	Friday 285.55				
	2184.2	2197.5	2211.1	2124.8	2239.5
	83.2				
...Cyl. Fulls	4			4	3
Cyl. Mts.	7			7	8
...age 1, 2 & 3	245/244/246	243/242/244	242/240/242	243/240/243	243/24.../246
Gland	✓	✓	✓	✓	✓
...Temp.	✓	✓	✓	✓	✓
...Vib.	✓	✓	✓	✓	✓
...Brg.	✓	✓	✓	✓	✓
...ster Pump	1 OFF Don	Rotate each Monday and record			
...y Line Flush					

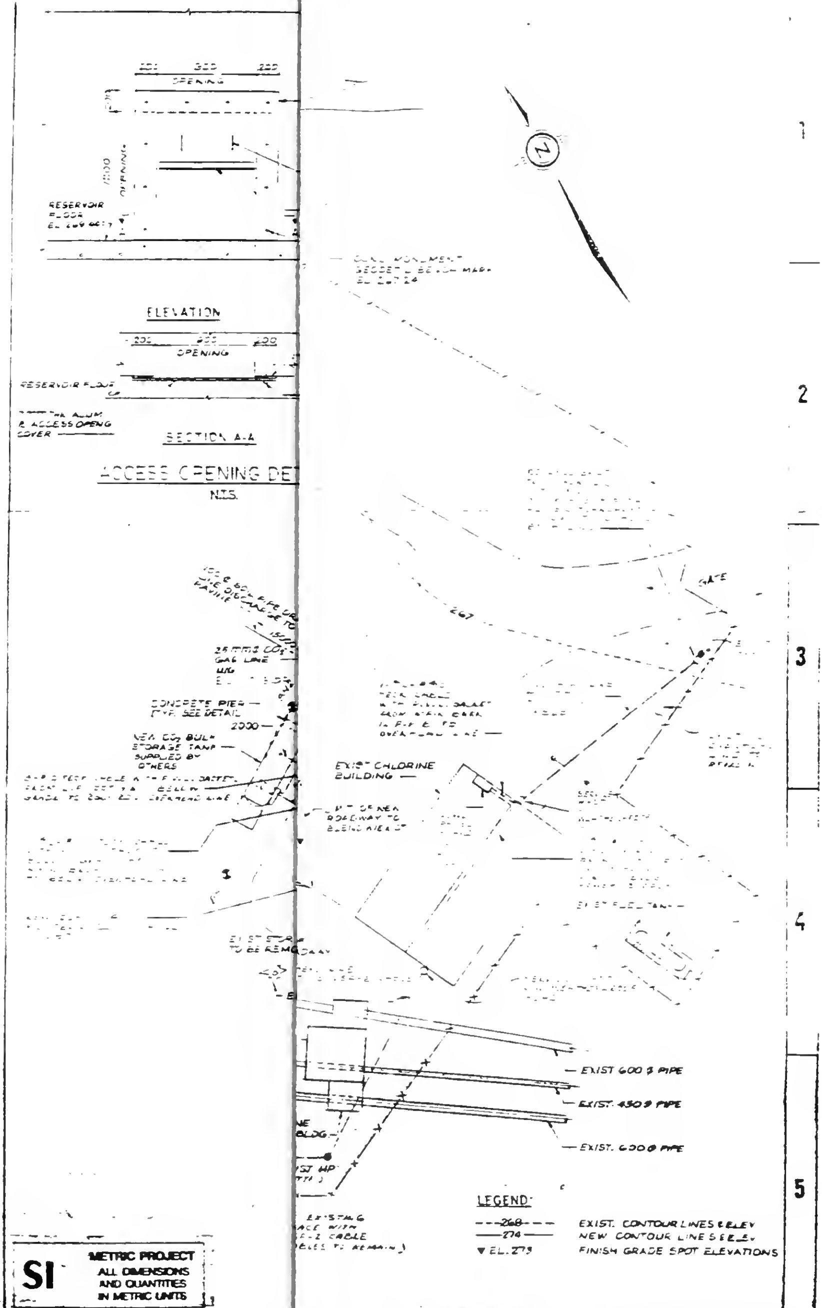
LAUNDRY	1.4. 8.0 8.15	1.4. 7.5 7.2	1.45. 8.1-7.93	7.5 Pl / 1.45 Cl	1.4. 8.03 8.0
RES	8.88	8.68	8.76		8.72
SINK	7.46	7.36	7.4	9.2 7.14	7.49
MESSWALL	1.40 8.2 - 8.0 1.3	7.58 7.3	1.5 8.2 - 8.0	~~8.3~~ 8.2 1.3	1.3 - 8.08 - 7.8

APPENDIX C

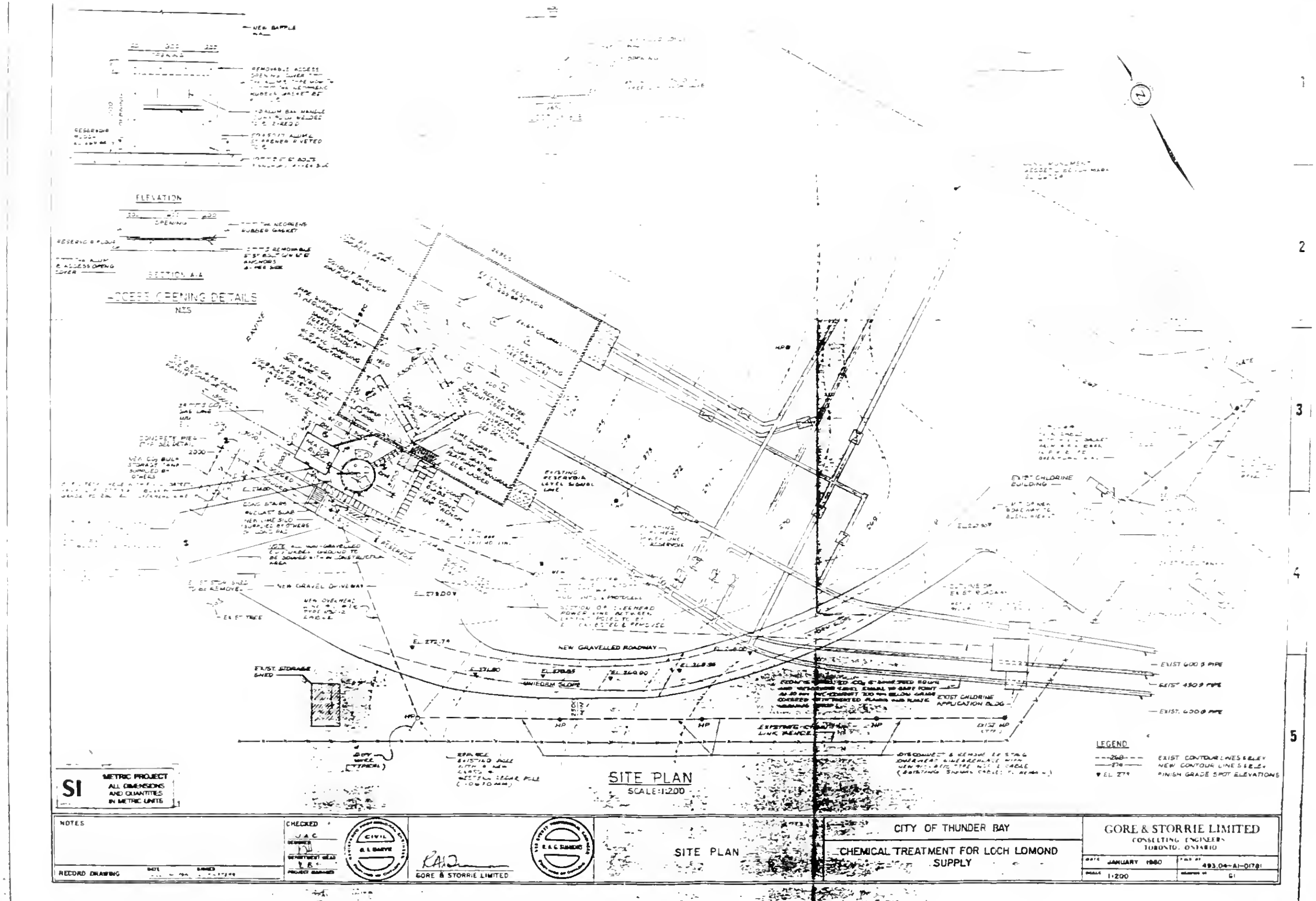
LOCH LOMOND WATER TREATMENT PLANT

PROCESS AND PIPING SCHEMATIC





NOTES	BAY	GORE & STORRIE LIMITED CONSULTING ENGINEERS TORONTO, ONTARIO
	LOCH LOMOND	DATE JANUARY 1980 — FILE NO. 493.04-AI-01781
RECORD DRAWING		SCALE 1:200 — DRAWING NO. 61


ELEVATION
SECTION A-A
ACCESS OPENING DETAILS
NTS
RAVINE
EXISTING RESERVOIR
EXISTING RESERVOIR LEVEL SIGNAL LINE
LIME SLURRY APPLICATION
NEW GRAVEL DRIVEWAY
NEW GRAVELLED ROADWAY
UNIFORM SLOPE
EXIST. STORAGE SHED
EXIST CHLORINE BUILDING
EXIST CHLORINE APPLICATION BLDG
EXIST. 600 ø PIPE
EXIST. 450 ø PIPE
EXIST. 600 ø PIPE
LEGEND
EXIST. CONTOUR LINES & ELEV.
NEW CONTOUR LINES & ELEV.
FINISH GRADE SPOT ELEVATIONS
SI METRIC PROJECT
ALL DIMENSIONS AND QUANTITIES IN METRIC UNITS
SITE PLAN
SCALE: 1:200
NOTES
RECORD DRAWING
CHECKED
GORE & STORRIE LIMITED
SITE PLAN
CITY OF THUNDER BAY
CHEMICAL TREATMENT FOR LOCH LOMOND SUPPLY
GORE & STORRIE LIMITED
CONSULTING ENGINEERS
TORONTO, ONTARIO
JANUARY 1980
1:200

TERMS OF REFERENCE

WATER PLANT OPTIMIZATION STUDY
PLANT INVESTIGATION AND PROCESS EVALUATION STUDY
TERMS OF REFERENCE

Purpose

To review the present conditions and determine an optimum treatment strategy for contaminant removal at the plant, with emphasis on particulate materials and disinfection processes.

Work Tasks

1. Receive a package of available information on the plant from the MOE. Review the information provided and meet with the MOE staff to discuss the project.

2. Document the quality and quantity of raw and treated waters. Along with Work Task 3, send a progress report to the Project Committee at the conclusion of this work.

3. Define the present treatment processes and operating procedures. Along with Work Task 2, send a progress report to the Project Committee at the conclusion of this work.

4. Assess methods of efficient particulate removal which would utilize the present major capital works of the plant. Evaluate the particulate removal efficiency and sensitivity of operation, assuming optimum performance of the plant. Along with Work Task 5, send a progress report to the Project Committee at the conclusion of this work.

5. Assess methods which would improve, if necessary, the disinfection practices of the plant, keeping in mind a desire to minimize the production of chlorinated by-products in the treated water. Along with Work Task 4, send a progress report to the Project Committee at the conclusion of this work.

6. Describe possible short and long-term process modifications to obtain optimum disinfection and contaminant removal, with emphasis on particulate removal and a desire to minimize the production of chlorinated by-products. Meet with the Project Committee at the conclusion of this work to review the report information.

7. Prepare 7 copies of the draft report and submit to the Project Committee.

8. Review the Project Committee's comments and prepare 25 copies of the final report.

11/08/86

1. RECEIVE A PACKAGE OF AVAILABLE INFORMATION ON THE PLANT FROM THE MOE. REVIEW THE INFORMATION PROVIDED AND MEET WITH THE MOE STAFF TO DISCUSS THE PROJECT.

Elements of Work

(a) Receive a package of available information from the MOE concerning the plant.

(b) Review the information and otherwise prepare for a meeting to initiate work on the project, including preparation of a schedule of manpower and staff requirements.

(c) Meet with the MOE to discuss the available data, the terms of reference, and the project staff and work schedule.

2. DOCUMENT THE QUALITY AND QUANTITY OF RAW AND TREATED WATERS. ALONG WITH WORK TASK 3, SEND A PROGRESS REPORT TO THE PROJECT COMMITTEE AT THE CONCLUSION OF THIS WORK.

Elements of Work

(a) Tabulate the daily raw and treated water flows for the last three consecutive years.

(b) Document the methods of measuring the raw and treated water flow rates, and assess the validity of the records.

(c) Prepare a monthly summary of maximum, minimum, and average flows for the three years. Address any discrepancies which exist between raw and treated flow rates.

(d) Review and assess the monthly maximum, minimum, and average per capita flow for the three years. Compare the plant data with typical per capita flows for the local region.

(e) Document a summary, based on at least three years of data, of the raw and treated water quality testing data for physical, microbiological, radiological, and chemical water quality information. Document as much data as is needed to show possible seasonal trends in water quality. Where possible, show corresponding sets of raw and treated water quality information. Document the source and methods used in determining all water quality information. Assess the validity of the data, comparing plant and outside laboratory data.

(f) Tabulate, for the last three consecutive years, where available, raw and treated water turbidity, residual aluminum, pH, and colour. Record other data, such as particle counting, suspended solids, and algae counting, which could reflect on particulate removal efficiency. These data should be used for assessment of the particulate removal efficiency of the plant. Document the source and methods used in determining all information. A comparison should be made between the plant and outside laboratory information to ascertain the relative validity of the data. For plant data, emphasis should be given to plant laboratory tests rather than continuous process control instruments.

(g) Tabulate, for the last three consecutive years, the raw water bacterial test information at the plant. Also tabulate the corresponding treated water tests at the plant which register positive results. Document the source and methods used for all data provided. This information should be used to assess the effectiveness of the disinfection practices at the plant.

(h) Identify and recommend other water quality concerns, not related to particulate removal or disinfection, which should be considered as part of the assessment phase of this evaluation program.

(i) Submit a progress report to the Project Committee.

3. DEFINE THE PRESENT TREATMENT PROCESSES AND OPERATING PROCEDURES. ALONG WITH WORK TASK 2, SEND A PROGRESS REPORT TO THE PROJECT COMMITTEE AT THE CONCLUSIONS OF THIS WORK.

Elements of Work

(a) Where drawings are available, assemble sufficient record drawings, of a reduced size, to document the general site layout and the interrelationship of major plant components. If not already available, prepare a process and piping diagram (PAPD) of the plant operations.

(b) Prepare a simplified block schematic of the major plant components.

(c) Prepare a photographic record of the plant facilities, illustrating all of the major plant components and chemical feed systems.

(d) Tabulate the design parameters for all of the major plant components, with emphasis on the process operations, including chemical feeds. This information, as a minimum, must be consistent with the DWSP Questionnaire and must be confirmed and verified by field observations.

(e) Prepare a brief summary of how the plant is operated, including chemical dosage control, such as jar testing information, filter backwashing procedures and initiation, and pumping and flow control.

(f) Document and assess any reported problems in plant operations and/or in the distribution system related to water quality.

(g) Tabulate the daily average chemical dosages for the last three consecutive years. Document the methods used to evaluate chemical dosages and establish the validity of the dosage information provided.

With regard to disinfection, tabulate the dosages of chlorine and disinfection-related chemicals such as chlorine dioxide. In addition, provide corresponding data on disinfectant residuals in the plant, such as free and total chlorine residuals. Also, provide chlorine demand tests where available. Again, document the methods of dosage evaluation and residual measurements, and establish the validity of the data provided.

(h) Submit a progress report to the Project Committee.

4. ASSESS METHODS OF EFFICIENT PARTICULATE REMOVAL WHICH WOULD UTILIZE TH PRESENT MAJOR CAPITAL WORKS OF THE PLANT. EVALUATE THE PARTICULATE REMOVA EFFICIENCY AND SENSITIVITY OF OPERATION, ASSUMING OPTIMUM PERFORMANCE C THE PLANT. ALONG WITH WORK TASK 5, SEND A PROGRESS REPORT TO TH PROJECT COMMITTEE AT THE CONCLUSION OF THIS WORK.

Elements of Work

(a) Using information provided in Work Tasks 1 and 2, evaluate the plant' particulate removal efficiency. The basis of minimum particulate remova should be 1.0 FTU, which is the maximum acceptable concentration of th Ontario Drinking Water Objectives (Table 1, page 2, Ontario Ministry of th Environment, Revised 1983). It should, however, be recognized that it i desirable to strive for an operational level which is as low a turbidit level as is achievable.

(b) Conduct an evaluation of possible optimum performance alternatives including jar testing of plant water samples.

(c) Evaluate the feasibility of optimum removals using the existing plan capital works. This evaluation should consider the worst case wate quality conditions, even though field testing data may not be availabl during the initial phase of the study (see Work Task 7).

(d) Describe the operational procedures, management strategies, and equipmen required for various feasible alternatives. Estimate chemical dosages level of operational expertise, and sensitivity of operation of th alternatives.

(e) Submit a progress report to the Project Committee.

5. ASSESS METHODS WHICH WOULD IMPROVE, IF NECESSARY, THE DISINFECTION PRACTICES OF THE PLANT, KEEPING IN MIND A DESIRE TO MINIMIZE THE PRODUCTION OF CHLORINATED BY-PRODUCTS IN THE TREATED WATER. ALONG WITH WORK TASK 4, SEND A PROGRESS REPORT TO THE PROJECT COMMITTEE AT THE CONCLUSION OF THIS WORK.

Elements of Work

(a) Using the information provided in Work Tasks 1 and 2, evaluate the plant's ability to disinfect the water. The basis of minimum disinfection should be to ensure a water quality as described in the Ontario Drinking Water Objectives (Ontario Ministry of the Environment, Revised 1983).

(b) Conduct an evaluation of possible optimum disinfection procedures for the plant, with consideration also given to the reduction of chlorinated by-products in the treated water.

(c) Evaluate the feasibility of the various alternatives using the existing plant capital works. Estimate the initial and final levels of chlorinated by-products for the various alternatives. Assess the relative merits of the alternatives.

(d) Describe the operational procedures, management strategies, and equipment required for the feasible alternatives. Estimate chemical dosages, level of operational expertise, and sensitivity of operation for the alternatives.

(e) Submit a progress report to the Project Committee.

6. DESCRIBE POSSIBLE SHORT AND LONG-TERM PROCESS MODIFICATIONS TO OBTAIN OPTIMUM DISINFECTION AND CONTAMINANT REMOVAL, WITH EMPHASIS ON PARTICULATE REMOVAL AND A DESIRE TO MINIMIZE THE PRODUCTION OF CHLORINATED BY-PRODUCTS. MEET WITH THE PROJECT COMMITTEE AT THE CONCLUSION OF THIS WORK TO REVIEW THE REPORT INFORMATION.

Elements of Work

(a) It is not the purpose of this study to provide a detailed implementation scheme for plant rehabilitation. It is, however, necessary to scope the feasible short and long-term process modifications required to achieve optimum disinfection and contaminant removals.

Prepare a list of modifications which should be considered for detailed implementation evaluation. Provide an estimated cost for each of the proposed modifications.

(b) Prepare a schedule for the list of modifications.

(c) Meet with the Project Committee at the plant site to review the proposed modifications.

7. PREPARE 7 COPIES OF THE DRAFT REPORT AND SUBMIT TO THE PROJECT COMMITTEE.

Elements of Work

(a) The report must include all the information reported previously in the study. The information must be organized and presented in a logical and co-ordinated fashion.

A general table of contents will be provided for organizing the material in a manner consistent with other plant reports.

(b) Submit the draft report to the Project Committee for review.

(c) Prepare a separate letter report containing a recommendation(s) concerning the need for additional field testing to cover water quality conditions not available during the period of this study. The Project Committee may decide to delay completion of the final report until field data can be obtained to confirm the predictions of performance for the worst case water conditions.

8. REVIEW THE PROJECT COMMITTEE'S COMMENTS AND PREPARE 25 COPIES OF THE FINAL REPORT.

Elements of Work

(a) Conduct additional field testing if required. Discuss the implications of the results with the Project Committee if the results differ from the predicted performance.

(b) Amend the report as per review comments, incorporating additional field data if required.

(c) Submit copies of the final reports to the MOE for distribution.